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Improving Management of Military Construction Planning and Design

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James L. Hathaway
Jordan W. Cassell

In cooperation with the Planning and Design Task Force
U.S. Army Corps of Engineers

October 1991

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REPORT DOCUMENTATION PAGE

Form Approved
OPM No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
October 1991

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Improving Management of Military Construction Planning and Design

5. FUNDING NUMBERS
C DACW31-90-D-0076

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Logistics Management Institute
6400 Goldsboro Road
Bethesda, MD 20817-5886

8. PERFORMING ORGANIZATION REPORT NUMBER
LMI–CE006R1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Department of the Army
U.S. Army Corps of Engineers (CEMP-ES)
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
A: Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The Corps of Engineers can improve the management of its planning and design program by helping customers to better define their design services needs and improve design budget estimates. A design estimating model can improve this capability. A model can also assist in allocating design funds to divisions and districts and in forecasting design workload requirements for various staffing levels. Costs for design services can be recorded using a new work breakdown structure. The reasons for lost design need better definition and lost design must be more thoroughly reported. For very large and complex projects, the Corps should use creative management concepts, separate organizations, and flexibility in interchanging construction and design funds.

14. SUBJECT TERMS
Planning and Design, P&D Funding, Design Services, Lost Design, Design Costs, Design Funds Allocation, Large/Complex Project Design, Work Breakdown Structure

15. NUMBER OF PAGES
150

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	18. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

LMI

Executive Summary

IMPROVING MANAGEMENT OF MILITARY CONSTRUCTION PLANNING AND DESIGN

The need to economize within the Department of Defense has led the U.S. Army Corps of Engineers (USACE) to review its planning, engineering, and design methods and operations. To do so USACE established a task force assisted by the Logistics Management Institute (LMI) that includes headquarters, field, and other Service representatives. That team developed recommendations for improving the utilization of planning and design funds through more cost-effective operations. The task force focused on four areas: design services, lost design, large and complex projects, and planning and design resource management.

In the area of *design services,* the team found that although USACE provides a full range of design services for its projects, some customers require more – special reviews, comprehensive interior design, and administrative requirements, including mail and reproduction. Those extra services are costly and many USACE customers do not realize their effect on the design cost of a project. We developed a computer model that incorporates historic design costs by facility category so that project managers can estimate typical costs of design services for each project. It will help USACE and the customer compare the incremental value of these services versus their incremental cost and should result in a more effective selection of additional services.

LMI also prepared a recommended work breakdown structure for the emerging Corps of Engineers Financial Management System that can be used to collect the costs of planning and design services at the desired levels of detail. When this structure is placed in service, it can provide a more accurate estimate of planning and design service costs and a more accurate means for tracking those costs.

LMI prepared a draft engineering regulation that is consistent with task force findings. It addresses the definitions of *lost design* (a design that has been scrapped because of extensive changes), suggests a format for its reporting, and presents a new

list of lost design reason codes. We believe that those definitions, format, and list will go far toward improving the quality of data on lost design.

The USACE needs to ensure that on unusually *large or complex projects* it employs creative and effective management concepts, including separate organizations, innovative procurement methods, and flexibility in the use of planning and design and construction funds. A team concept involving the USACE management team, owners, representatives, and design and construction contractors is needed. Owner participation in such ventures is particularly vital to ensure that requirements are fully understood and that continuity is provided from the time design and construction start until the facility is ready for initial operation.

As part of this task, LMI reviewed *resource management* and updated the USACE computer model, Corps of Engineers Resources and Military Manpower System, used to project resource requirements for design resources for future military construction programs. We also developed a separate computer model to assist design agents in assessing necessary planning and design workload, given the expected staffing levels of in-house engineering and design personnel.

Both LMI and the task force believe that by adapting each of these recommendations and applying the methods and tools resulting from this research, an improvement in the delivery of sound designs, lower life-cycle project costs, and a more-effective utilization of scarce planning and design funds will result.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

THE PLANNING AND DESIGN PROGRAM

The U.S. Army Corps of Engineers (USACE) is responsible for design and construction of the entire Army Military Construction (MILCON) program and a major portion of the Air Force MILCON program. It is also responsible for the design of other facilities programs, such as those funded by installations using their own funding sources including the operations and maintenance, Army (OMA) appropriation. Although the findings, conclusions, and recommendations of this report center on the MILCON planning and design (P&D) program, they are also applicable to the other USACE design programs.

The design of facilities acquired through the MILCON appropriation is generally funded 2 years before receiving construction funds. The design funds are included in a MILCON subaccount titled "Planning," more commonly referred to by the Military Services as P&D. The P&D account contains a single amount for design of all projects rather than a separate design amount for each project. Like other defense programs, MILCON is included in the DoD planning, programming, budgeting, and execution system (PPBES), which projects total defense programs and resource requirements at least 6 years into the future. As the content and funding levels of future year MILCON programs change, so too must the P&D funding levels.

IMPROVEMENT INITIATIVES

In recent years, USACE has encountered a decline in construction programs and design funds, and during the same period, design costs have increased. That combination evoked a need to review key facets of the P&D program. The Logistics Management Institute (LMI) was tasked to study major contributing factors affecting the disparity in the funds-versus-workload issue and recommend measures to improve performance. LMI concluded that the USACE needs a more accurate

method to calculate the requirement for P&D funds and once that calculation is corrected, it needs improvements in managing the design program.[1]

One of the most common measures of design performance is the ratio of design costs to construction costs. We found significant variations in the ratios among various sizes of projects, their funding categories, and the types of projects being built. Typically, a project costing less than $1 million in construction funds requires more than twice the percentage of design dollars required by a project costing over $5 million. For that reason, we assumed that design work must encompass a significant fixed-cost component, which can be reduced. To make any such reduction, it is first necessary to better understand the requirement for all design services and costs. Similarly, we believe that to improve design management the USACE needs methods to reduce wasted design and improve estimating techniques for design costs and design manpower.

TASK FORCE CONCEPT

To effectively review procedures and implement improvements in the design program, USACE established a task force comprised of people from its field offices and the headquarters staff and representatives from the Air Force and Navy. LMI was tasked to support the task force and prepare this final report. The task force effort was divided into five separate subtasks:

- Subtask 01 – Lost Design
- Subtask 02 – Large/Complex Projects
- Subtask 03 – CERAMMS[2] Manpower Model Enhancement
- Subtask 04 – Revised P&D Estimating and Allocating Procedures
- Subtask 05 – Schedule of Design Services.

RESEARCH AREAS

We restructured the subtasks into research areas for ease in presenting the task force findings, conclusions, and recommendations. Those areas form the basis for the

[1]LMI Report AR001R1, *Military Construction Planning and Design Funding Requirements*, James L. Hathaway, Eric M. Small, and Jeffrey Hawkins, November 1990.

[2]CERAMMS, Corps of Engineers Resources and Military Manpower System, a model developed by LMI to forecast manpower requirements based on the USACE facilities construction program.

remaining chapters of this report and its appendices. A brief description of the objective for each research area is presented in the following subsections.

Design Services

Chapter 2 describes the range of design services currently provided to USACE customers and the extent to which each is used in the design process. The task force believes that if the USACE can develop a better understanding of the various design services, it can make more rational and cost-effective decisions on providing them.

Lost Design

We found anectdoctal evidence in support of the belief that a significant amount of design effort is wasted on changes, delays, cost impacts, or combinations of those factors. (We refer to such wasted design as *lost design*.) Chapter 3 reviews the definitions, reporting requirements, and reasons for lost design and identifies some initiatives that will help to curtail its current high rate.

Large and Complex Projects

The task force reviewed samples of large and complex USACE projects, exclusive of medical facilities projects, to determine their special requirements for P&D services. It then compared those USACE projects with selected projects in the private sector. The task force's findings and conclusions in this area are presented in Chapter 4.

Resource Management

In Chapter 5, we describe two complete models that we developed to improve USACE's ability to predict manpower, funds, program requirements, and services for planning and design.

In Chapter 6, we summarize the recommendations from each of the research areas and present a proposed course of action that will reduce the cost of planning and design and improve the management and delivery of USACE's planning and design products.

CHAPTER 2

DESIGN SERVICES

A vital factor in controlling costs for any product or service is a clear understanding of the nature of each of its component parts and an ability to record accurately the costs of those parts. The task force found that in the case of design services, costs are not well documented. Moreover, because there has been little incentive in the past to control design costs, no serious effort has been made to examine the individual design services. To improve the management of P&D, USACE needs to understand the costs of its individual design services and give its customers the opportunity to specify the services required.

In the following sections, we contrast the approach to design services used in the private sector with those provided by USACE and suggest a menu from which services can be selected. To account for costs, we have developed a work breakdown structure using a suggested format for the new Corps of Engineers Financial Management System (CEFMS) that can capture design costs at various levels of detail. Finally, through a customer-wide survey we have identified the frequency, value, and quality of USACE design services.

FULL SERVICE SUPPORT

District offices of the USACE can provide a full menu of engineering and design services to their customers. Those services range from early planning during the project formulation stage through the preparation of plans and specifications to the provision of technical support during and after construction. Planning, engineering, and design services are usually provided by the district engineering divisions. The construction divisions oversee the construction phase, including support for the area and resident field offices.

Most of the planning services, usually referred to as advance planning, are provided by the installation from base support funds. If the level of effort or technical difficulty is beyond the capability of the installation's director of engineering and housing (DEH) staff, the installation may request engineering support from the USACE district. The district often provides master planning, soils analysis,

environmental studies, and surveys to augment the DEH capability. USACE has no oversight responsibility for the planning functions at an installation; that remains the responsibility of the installation and its major command (MACOM). A USACE district office responds only upon request and only when reimbursement for the planning services is provided. For smaller construction projects, the DEH may also be able to produce plans and specifications, often using an architect-engineer (A-E) firm retained by the district under an indefinite delivery type (IDT) contract. However, for major projects, most designs, particularly those funded by the MILCON appropriation, are provided by the USACE district offices.

The district offices assign the construction phase of their projects to their construction divisions for project oversight. Although design services may be required during that stage of work, the project designer is usually requested to provide support only if the construction division finds it needs help. That procedure is a notable departure from that of the private sector in which the designer typically is involved in all phases of planning, design, and construction.

Customers of USACE are seldom aware of all the planning and design services provided since they become involved primarily during the early planning phase and design reviews. Moreover, USACE acts on behalf of the "owner," freeing the installation from many of the responsibilities it otherwise would incur if acting as a client in the private sector. The private-sector client is typically involved in all phases of the design and construction process including selection of the A-E firm, administration of the contract, and management of the funds; the Corps, as charged in its role as design and construction agent, provides these services acting for the installation or MACOM.

DESIGN SERVICES MENU

To distinguish between services that are basic requirements for all designs and those that should be considered optional, the task force developed a recommended list as a guide.

The USACE provides approximately 80 percent of the Air Force MILCON design and construction services. As a major USACE customer, some Air Force major commands (MAJCOMs) have developed lists of specific services needed for individual projects. The Air Force programs and budgets its own P&D funds to support future MILCON programs, and thus has a vested interest in controlling its design costs.

Through agreements between the USACE divisions/districts and Air Force MAJCOMs, projects are currently being tailored to provide services the customer requires and the estimated costs for those services.

The task force decided that it would use the Air Force lists of services as a point of departure for developing a USACE-wide menu of design services. The American Institute of Architects (AIA) also uses a list of services in its recommended contract form, *Standard Form of Agreement Between Owner and Architect*, Document B-141, to specify for clients those services that are standard and those considered optional. We also examined services provided for major design contracts for large projects.

In developing a recommended menu of P&D services, we determined that it was important to be able to relate USACE services to those prescribed in the private sector. Firms providing services to USACE should have a common private sector frame of reference. Another criterion was to make a list of additional services available if the customer requests services beyond the basic service level. Because the customer can also request planning services, that are usually provided by the installation, we considered a separate menu for advance planning services to be an integral part of the menu requirement.

Tables 2-1 and 2-2 are the suggested menus for engineering and design services and advance planning services, respectively. They have been consolidated from the AIA Document B-141, the Air Force lists, and sample USACE project lists. They do not identify every possible service in detail but do establish services categories from which specific services can be derived. Note, for example, the category "Surveys" shown as Item 11.B. in Table 2-1; since numerous types of surveys might be required in support of a design project, the specific survey needed would have to be identified and a separate cost estimate developed to aid the client in selecting this service. Similarly, in Table 2-2, many different types of environmental or economic studies might be required to support a project during its advance planning phase.

The service list in Table 2-1 is not a complete list of all possible design services. It is, however, indicative of the full range of design services provided to customers. Clients of A-E firms are typically provided a list of construction contracting services in the same document or contract for which design is specified. Such services include:

TABLE 2-1

MENU OF ENGINEERING AND DESIGN SERVICES

1. Management	6. Electrical/electronic
A. Program	A. Exterior
B. Project	B. Interior
C. Design	C. Communications/data
2. Architecture	D. Intrusion detection
A. Site design	E. Energy monitoring/control
B. Building design	F. Electromagnetic interference
C. Interior design	7. Specifications
D. Landscape design	8. Cost engineering
E. Acoustic design	9. Value engineering
3. Civil	10. Constructability review
A. Soils	11. Other reimbursable
B. Drainage	A. Multiple reviews
C. Utilities	B. Surveys
D. Ground structure	C. Renderings/promotions
4. Structural	D. Regulatory (permits)
A. Building and foundation	E. Travel
B. Heavy	F. Reproduction
5. Mechanical	G. Mailing
A. HVAC	H. Operations and maint manuals
B. Plumbing	I. Client training
C. Fire protection	J. Legal
D. Elevators and escalators	K. Other
E. Material handling equipment	
F. Energy efficiency/solar	

Note: HVAC = *Heating, ventilating, and air conditioning.*

- Bid evaluation and negotiation assistance
- Periodic site inspections
- Full time site representation
- Project materials purchasing
- Shop drawing review

TABLE 2-2

MENU OF ADVANCE PLANNING STUDIES

1. Planning
A. Master planning
B. 1391 Preparation and review
C. Project development brochures
2. Environmental
3. Economic
4. Cultural/historic resource
5. Feasibility and survey
A. Engineering
B. Asbestos
C. Existing conditions
D. Energy
E. Utility
F. Traffic
G. Materials
H. Site investigations
I. Soil borings and analyses
6. Other
A. Emergency mobilization
B. Hazardous and toxic waste

Note: 1391 = DD Form 1391, ***Military Construction Project Data***

- Change order preparation
- Pay estimate verification
- Contract document conflict resolution.

The USACE customer is involved to a much lesser extent in the construction phase of the project than in the design phase; during construction, the involvement is limited to coordinating site support. The USACE district construction divisions and their field and area offices are charged with managing the construction phase. Design assistance is provided to the construction organizations by the engineering divisions or A-E firms only if requested by the construction offices.

WORK BREAKDOWN STRUCTURE

If P&D costs are to be controlled, cost managers need a detailed description of the various cost components. If management decides that P&D costs must be reduced by a certain percentage, then managers at division, branch, and section levels must understand where their costs are being lodged, so that less important tasks can be reduced or discontinued. Managers in Government agencies too often think in terms of discretionary costs as those associated with travel, training, equipment, and supplies. Labor costs, however, are by far the greatest cost element for most agencies, and the work employees perform represents the greatest opportunity for cost control. In order to manage work at different levels in organizations, the work must be divided into enough finite work items that managers can decide where improvement is needed.

Since the cost of individual design services is not available from USACE records, accounting and timekeeping procedures will have to be modified if actual costs are to be collected at the work-item level. USACE is currently revising its information systems thoroughly, and that revision includes the replacement of its finance and accounting systems. As part of the effort, a new work breakdown structure that will provide additional management information is being developed. The new structure will enable labor hours and costs to be collected consistently throughout USACE at the work-item level.

Using a project as the principal product below which work is to be subdivided, the task force developed a work breakdown structure for two of the five phases of a project's life cycle: (1) advance planning and (2) engineering and design. This structure will be integrated with the real estate, construction, and operations phases. Figure 2-1 illustrates this scheme, with the project designated as Level I and the five phases as the work breakdown at Level II immediately below the project.

Advance Planning

Figure 2-2 is the work breakdown display for advance planning. The six work elements of Level III are the primary work areas comprising advance planning. Appendix A contains a more detailed breakdown of work elements through Levels IV, V, and VI. For the Level II functions of advance planning and engineering and design, advance planning work is usually performed on a reimbursable basis at the

customer's request; therefore, work performed in that phase normally would not be charged to the P&D account.

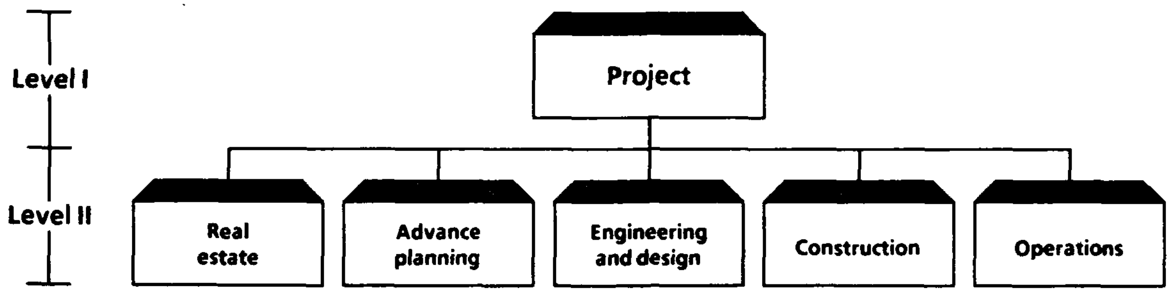

FIG. 2-1. WORK BREAKDOWN STRUCTURE – LEVELS I AND II

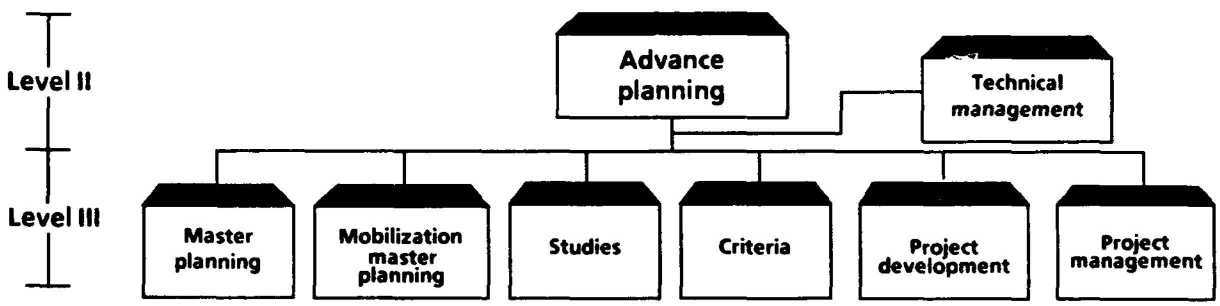

FIG. 2-2. WORK BREAKDOWN STRUCTURE
ADVANCE PLANNING – LEVELS II AND III

Engineering and Design

Using the same scheme, we generated a similar display for the engineering and design phase (see Figure 2-3). Project management and technical management are shown for both the advance planning and engineering and design phases since those work elements are common for each phase. Because the project management function, now operating under the life-cycle project management program, will be required during the construction phase, we presume that this Level III work element will also be required for construction. Expanded detail for the engineering and design work element below Level III can also be found in Appendix A.

The suggested work breakdown structure can be modified by expanding it to greater detail at lower levels. For most projects this expansion should not be

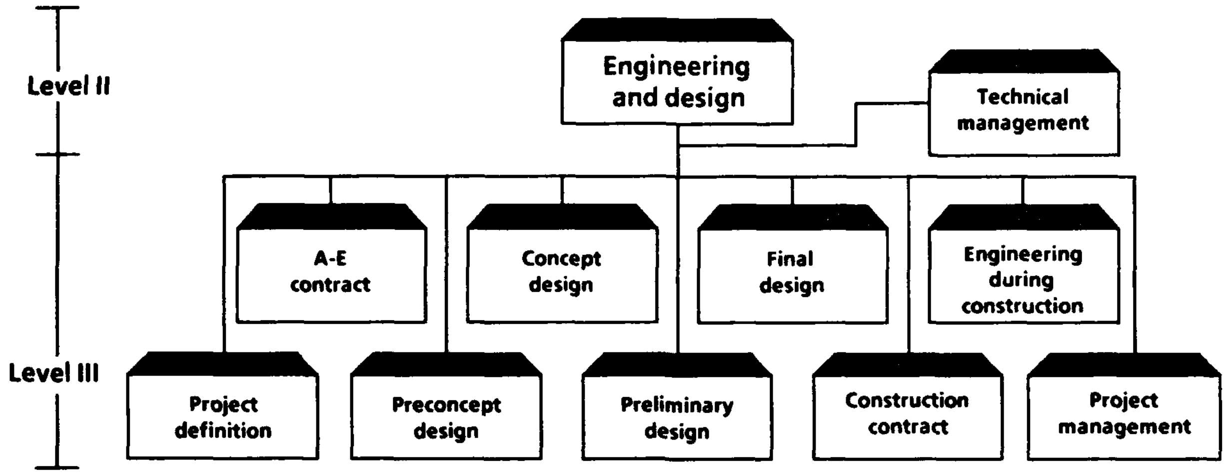

FIG. 2-3. WORK BREAKDOWN STRUCTURE
ENGINEERING AND DESIGN – LEVELS II AND III

necessary. The task force emphasized that the level of detail for every project should vary. It will depend upon the particular requirements of district and division managers. Cost/labor information should only be collected when it has utility to managers; otherwise, the timekeeping function can become an expensive administrative burden that will soon be abandoned. If data are to be collected, however, this structure, or one that achieves the same objectives, should become the basis for all such work element information.

DESIGN SERVICES AND WORK BREAKDOWN

Cost data for most design services can be collected through use of the above work breakdown structure. Other services will need to use the labor code of one office, such as the Legal Office, to capture special costs. Some costs that are distributed throughout the USACE district – accounting and personnel support are two examples – must necessarily be captured through the district overhead rate unless large segments of such work can be charged directly to specific projects.

In Chapter 5 we present a model that can be used to help estimate the costs of design services. The parameters for that model are based on historical data and the judgments of experienced personnel familiar with design services. As more accurate data are collected from CEFMS and its new work breakdown structure, that model can be modified to produce more accurate design cost estimates. Over time, work

breakdown cost accounting will enable each district and division to obtain cost information for any work element necessary for sound management decision making.

DESIGN SERVICES SURVEY

One of the task force's requirements was to evaluate design services by surveying USACE customers. The survey was to cover design services quality, timeliness, cost, frequency of use, and value to the customer. The survey was divided into two categories for evaluation. The first category was planned to provide an evaluation of the basic design products or services offered to all projects. The second category focused on special design services. A separate section of the survey was reserved for additional comments that respondents wished to append. Included in this latter section were services that USACE should either add or delete from its product line. We summarize that part of the survey following evaluation of the basic and special categories of services.

Basic Design Services

The basic design services are early preliminary design (through 10 percent design completion), concept design (through 35 percent design completion), and final design (100 percent design completion). These stages are common to most construction project designs although the early preliminary stage is sometimes included in the concept design stage and not separately identified. Many of the design services listed in the menu of Table 2-1 are included in these basic products, depending upon the project requirements. For example, architectural, structural, and electrical design services are required for nearly all building designs. Intrusion detection, elevators, or solar energy systems might be required for a select few facilities. Nevertheless, each is considered a part of the basic design product, depending on the individual project criteria.

For basic design services we asked the survey respondents to evaluate technical quality, timeliness, and cost. For both the basic services and special services we asked that separate evaluations be given for the three project size categories – projects less than $1 million, projects between $1 million and $5 million, and projects greater than $5 million. In previous research, we found a significant differential in design cost between projects in these size categories. The task force believed that a similar difference may exist with the evaluation of design services.

Special Design Services

Predesign services, special reviews, presentations, and client training are considered additional services that require effort beyond the normal level needed to deliver the design product. These special design services have to be defined early so a customer can decide how much effort must be expended to satisfy design requirements. At the same time, customers should expect to experience higher design costs when they require special services exceeding those normally provided with basic design products.

Our objective for special design services was to determine whether any of the services being provided could be reduced or eliminated. For each service, the questions were targeted toward determination of how often the service was used, what its value to the customer was, and what its quality was. A copy of the questionnaire used for this survey is presented in Appendix B.

SURVEY RESULTS

We sent 186 questionnaires to USACE customers. We sent another 52 to USACE field commands to determine how their assessments compare to those of their customers. A summary of the responses is shown in Table 2-3. We consider the response rate for this survey extremely good, particularly since a number of the respondents have only limited occasion to use USACE design services.

TABLE 2-3

PLANNING AND DESIGN QUESTIONNAIRE RESPONSE

Questionnaires	Army	Air Force	USACE	Total
Number sent	151	35	52	238
Responses	70	20	42	132
Rate	46%	57%	81%	55%

Of the 90 Air Force and Army customer responses, an average of 14 projects per customer have been designed by USACE each year. A summary of those projects by

size category (dollar value of construction) is presented in Table 2-4. Table 2-5 displays the distribution of those projects by fund type.

TABLE 2-4

PROJECT SIZE DISTRIBUTION

Projects < $1 million	Projects $1 million – $5 million	Projects > $5 million
47%	36%	17%

TABLE 2-5

PROJECT FUND TYPE DISTRIBUTION

MCA	MCAF	MCAR/AFR	OMA/AF	FHA/AF	Other
21%	15%	5%	32%	6%	21%

Notes: MCA, MCAF, MCAR/AFR = Military Construction, Army, Air Force, and Army/Air Force Reserve, respectively; OMA/AF = operations and maintenance Army/Air Force; FHA/AF = Family Housing Army/Air Force.

Basic Design Services Evaluation

In general, we found no significant dissatisfaction with the basic P&D services provided by USACE. The median responses from both customers and USACE field commands fell between the medium and high ratings for technical quality. The USACE usually delivers its design products on time and generally maintains costs close to or slightly higher than the amount estimated. In comparing responses from the two customer groups and the USACE field commands, the Air Force customers were the most critical of the services received. The Army customers were less critical and the USACE field activities were generally satisfied with the services they provide.

These results were not unexpected. The Air Force MAJCOMs manage their own MILCON P&D funds and seem very conscious of obtaining maximum quality design on time at lowest cost. Army commands, on the other hand, rely on USACE to manage their MILCON P&D funds. Thus, the Air Force evaluations tend more to

emulate a private-sector/customer relationship with USACE than do the Army installations.

Special Design Services Evaluation

This part of the survey was divided into three sections: predesign services, P&D management services, and special services. Predesign services are those typically required before beginning the actual design process and paid for from installation funds. More often than not the installation will provide its own predesign services to develop programming documents in support of the projects. Planning and design management services include project management, design reviews, contracting, construction support, and value engineering. Special services include interior design, promotional material (renderings, models, and photos), printing, mail, legal services, operations and maintenance (O&M) manuals, and client training.

Our analysis of the response data concentrated on those services that fell outside the normal distribution of responses, particularly those toward the lower (adverse) end of the rating scale. If a particular service is rated low value, it could be a candidate for elimination or reduced effort; if the service is rated high value but low quality, efforts should be made to improve its quality. Similarly, services that are used frequently probably deserve higher levels of management attention than those that are seldom used. Projects in the less than $1 million category received lower ratings than the larger projects, principally because many of the services are not required for the smaller projects.

Appendix C presents a summary of the ratings above and below the normal distribution of responses to the survey. The following subsections cite the services that deserve separate consideration for remediation:

Predesign Services

- *Economic studies.* The value of this service fell below normal; however, since its frequency of use was also low, no change may be required.
- *Cultural and historic studies.* The quality ratings for this service were high; however, its infrequent use and doubtful value could indicate that greater effort is expended for this service than is required.

Planning and Design Management Services

- *Value engineering (VE).* The dissatisfaction of some customers with VE services could indicate a misunderstanding of its purpose. There is a perception that if the designer had done a good job the first time, VE would be unnecessary. Recent audits of the VE program, however, indicate that increased emphasis on VE is warranted.

- *P&D support of construction management.* The quality of this service provided for projects under $5 million was rated lower than normal.

Special Services

- *Interior design.* The value of interior design was rated low for projects below $5 million and the quality was rated low for all size categories. With increasing emphasis on quality of life, improvements in this service appear to be required.

- *O&M manuals.* This service was rated high in value for large projects but was rated low in quality for all size categories.

- *Client training.* Similar to O&M manuals, this service was also rated high in value but low in quality.

Additional Comments

We found this part of the survey to be extremely useful inasmuch as it was a place in which the respondents could address issues not included in the ratings. Some of these comments went beyond design services and touched on installation and construction support. We highlight only those issues for which we had repeated comments.

- *Planning services.* USACE should provide a more complete range of services to support installation-level planning. Preparation/review of DD Form 1391 programming documents, master planning, and other planning studies require USACE expertise.

- *Environmental services.* Strong centralized leadership is needed in this rapidly evolving and highly specialized field. Assistance in obtaining permits, interpreting regulations, and contracting for hazardous and toxic waste (HTW) removal and environmental restoration is of great importance to most installations.

- *Facilities management services.* Provision of small contracts, particularly for local A-E services; job order contracts for repairs and minor construction; and maintenance service contracts is a vital service for installation support. Procedures for their delivery in a streamlined and cost-effective manner

need to be improved. Alternatively, more contracting authority should be given to the installation directorates of contracting (DOC) to provide these services.

- *Computer aided design (CAD).* CAD services need to be better integrated into installation support. System compatibility between USACE districts and installations is a major issue.
- *Project integration.* Project managers (PMs) need to become more involved in all phases of a project, from planning through construction. They need to be more available to the customer on site during design and construction. As projects proceed from the planning phase through the design and construction phases and then to the operational facility stage, only limited continuity occurs from one phase to the next.
- *Post-construction support.* Too often projects are turned over to the customer with inadequate documentation (O&M manuals) and deficient training. PMs are too busy with their next project and getting funds obligated to help the installation resolve the new project's problems.
- *In-house costs.* The customer believes costs for USACE direct effort, when burdened at current overhead rates, are extremely high. These rates cause customers to favor using A-E firms or doing more work through the DEH staff. A number of comments that favored reducing design reviews and other in-house services were rooted in the concern over high USACE costs.

CONCLUSIONS

The following subsections summarize the major conclusions derived from findings in each of the above topic areas.

Design Services Menu

The USACE should provide a menu of design services for use in tailoring work performed on each design project and for helping in the development of cost estimates. One solution is to develop a computer model based on historic design costs and basic service requirements.

Work Breakdown Structure

The USACE needs a structure for collecting design services costs. A work breakdown structure being developed for the new CEFMS cost accounting system will facilitate the recording of design services costs for both the advance planning and the engineering and design phases of a project.

Design Services Survey

- Although we did not identify any design services that clearly warrant elimination, VE appears to require review, both to inform the customer of its purpose, and to confirm that the level of VE effort is correct.
- The quality of a number of services needs to be improved; foremost among these are interior design and postconstruction support (O&M manuals and client training).
- The USACE needs to devote more attention and emphasis on the delivery of planning, environmental, CAD, and facilities management services.
- The customer desires more integration of each phase of design and construction. The PMs need to be more accessible and visible to the installations.
- Customers consider the cost of doing business with USACE offices to be excessive; it is driving some customers to seek alternate means of providing design services.

CHAPTER 3

LOST DESIGN

Changes often occur in the course of designing MILCON projects, and those changes often require that the initial design be scrapped or modified. Designs that cannot be salvaged are considered lost, and USACE believes a greater amount of lost design occurs than is reported. If the amount of lost design is known and its reasons identified, action can be initiated to reduce it, and that reduction will improve the effective use of design funds.

The task force concentrated on identifying lost design, tracking it through selected projects, and assessing how the different districts managed the process of reporting that lost design. We found little consistency in understanding the definition of lost design or in the way it is reported.

DEFINITION

The terms "breakage" and "lost design" have been used interchangeably; however, that is an incorrect usage. The P&D task force recommends that the following definitions be accepted by the USACE and used:

- *Lost design.* Design that has incurred a cost and that must be scrapped and/or redone prior to award of a construction contract because of changes in the scope of a project, criteria, weapons system requirements, design error or any other reason that invalidates portions of a design is lost design. Design of an unawarded construction contract additive bid item is included as lost design. Design changes that do not result in increased design cost and VE studies and any modification costs related to a VE study are not included as lost design.

- *Design breakage.* Design that has incurred a cost for any project not planned to be completed as part of an ongoing or planned construction program is design breakage. Design breakage includes project cancellations and projects deferred beyond the Six Year Defense Program (SYDP). Design breakage is not reported as lost design. Projects previously reporting lost design that subsequently fall into the design breakage category shall have all design costs reported as design breakage.

The terms "lost effort" and "lost design effort" are also used interchangeably with lost design, but since neither is prescribed by higher authority and both can lead to confusion, the task force believes their use is inappropriate. We also found that some districts include unawarded additive bid items as lost design while others do not. That design effort falls within the intent of lost design and is so defined. Arguments can also be made to include modifications resulting from VE studies as lost design. The task force believes, however, that the overriding consideration should be to avoid associating the negative stigma of lost design with the VE program. Since lost design must be reported annually to Congress, the task force believes it is important that USACE definitions be consistent with those of the other Services. Naval Facilities Engineering Command (NAVFAC) representatives confirmed that they plan to use definitions similar to those above.

REASONS

Although lost design is usually considered a negative attribute of the P&D program, some lost design is inevitable in ensuring that a project meets its requirements, is configured properly, or is sited n the best location. Lost design can result from errors in the design process, but far more often it is the result of a customer's changed requirements or of changes imposed on the customer by higher authority. To better manage lost design, it is imperative that we have a common understanding of the reasons that it occurs.

The task force determined that reasons for lost design could be grouped into the four general categories:

- *Higher authority changes.* Changes caused by actions initiated above the MACOM/MAJCOM level.
- *User changes.* Changes caused by actions initiated at the MACOM/ MAJCOM or installation levels.
- *Cost constraints.* Designs that must be revised because they would result in projects exceeding available funds.
- *Design error or omission.* Designs that are in error caused by either the design agent or its A-E firm.

Our preliminary research revealed that most design changes were imposed by the customer or higher authority. We subsequently confirmed that some of those apparent reasons were associated with a lack of funds, which might suggest the use of

the cost constraint category for reason code identification. Since a funding constraint at higher levels may not be apparent to field offices, we defined the cost constraint category to include only those elements under control of the field-level customer/design agent team. A more definitive description of these four categories and the reason codes assigned to each are provided in Appendix D.

REPORTING

The Corps of Engineers Automated Management and Progress Reporting System (AMPRS), a system that keeps track of all MILCON and other military programs, reported that lost design accounted for about 7 percent of the total P&D cost for the program years (PY) 1987 through 1989 MILCON programs. The Corps of Engineers Management Information System (COEMIS) reported approximately 9 percent for projects in the same program years. Some USACE representatives believe that the actual amount of lost design may be closer to 15 to 20 percent of the design program. Until reporting is more accurate, the USACE will not be able to determine the cost of lost design.

The important factors in reporting lost design are a clear understanding of its definition, a concise coding of its reasons, and a satisfactory method of collecting the information. Our research found that each district had devised its own format for collecting lost design information. Few of these formats were similar and most were difficult to interpret. Many design managers in the field expressed belief that the cumbersome reporting process dissuades districts from reporting lost design.

The USACE should prescribe a common format for reporting lost design by all district design offices. In Appendix E, we present a proposed format that the task force developed from various district samples. Additionally, the form contains the reason codes shown in Appendix D and the definitions of lost design and breakage presented earlier in this chapter so that the reporting official has all the guidance required in a single document. The form can easily be converted to automated format and its data extracted for reporting in both the AMPRS and COEMIS. Changes will be required in those two systems to accept the expanded reason codes; however, with current changes underway in CEFMS, incorporating the revised reason codes is timely.

PRIMARY CAUSES

The task force searched for methods to reduce lost design by placing priority on those areas that resulted in the greatest level of lost design cost. We conducted a special survey of districts to summarize the cause of lost design reported for all projects from 1987 to the present. That survey revealed that over 80 percent of the lost design cost arose from user changes to criteria, scope, or siting. A separate analysis of the FY89 MILCON program revealed similar results. Of the 266 projects reporting lost design cost, 228 projects or 86 percent, indicated that the cause was user change or higher authority change, and that those changes accounted for 93 percent of the total lost design dollar value. We then decided to use the revised reason codes and conduct an "Expert Choice" process to compare data collected from these analyses and the informed judgment of design experts.[1] The process indicated that between 70 and 75 percent of lost design occurred because of user or higher authority changes. Results of these summaries and analyses are contained in Appendix F.

The task force believed it was important that, along with our assessment of the frequency of lost design causes, we also assess their relative cost impact. During the Expert Choice process, we also considered the cost impact of each reason code on lost design. By combining cost and frequency, we determined a more accurate measure of the relative importance of each reason code. Of the total 16 reason codes, user changes brought about by criteria, weapon system, and scope changes accounted for 81 percent of the total cost of lost design. Design errors and changes in site conditions accounted for a significantly smaller cost and the remaining reasons even less. Table 3-1 lists the primary reason codes for lost design in order of their relative cost impact. Figure 3-1 depicts an organizational relationship of the more significant reasons for lost design.

CHANGE REDUCTION MEASURES

The task force queried its own members and selected representatives from other commands and installations and other Services for suggestions on how user changes can be reduced or better managed. The root causes of user changes nearly always stem from inadequate project planning. Project planning originates with weapon

[1]Expert Choice is a commercial software package used for analytic hierarchical processes to aid in rank ordering judgments of informed participants.

TABLE 3-1

PRIORITY CAUSES OF LOST DESIGN COST

Rank order	Reason code description	Cost impact index – %
1	User changes – criteria	50
2	User changes – weapons system	17
3	User changes – scope	15
4	Design error or omission	4
5 – 16	Remaining (12) causes	14

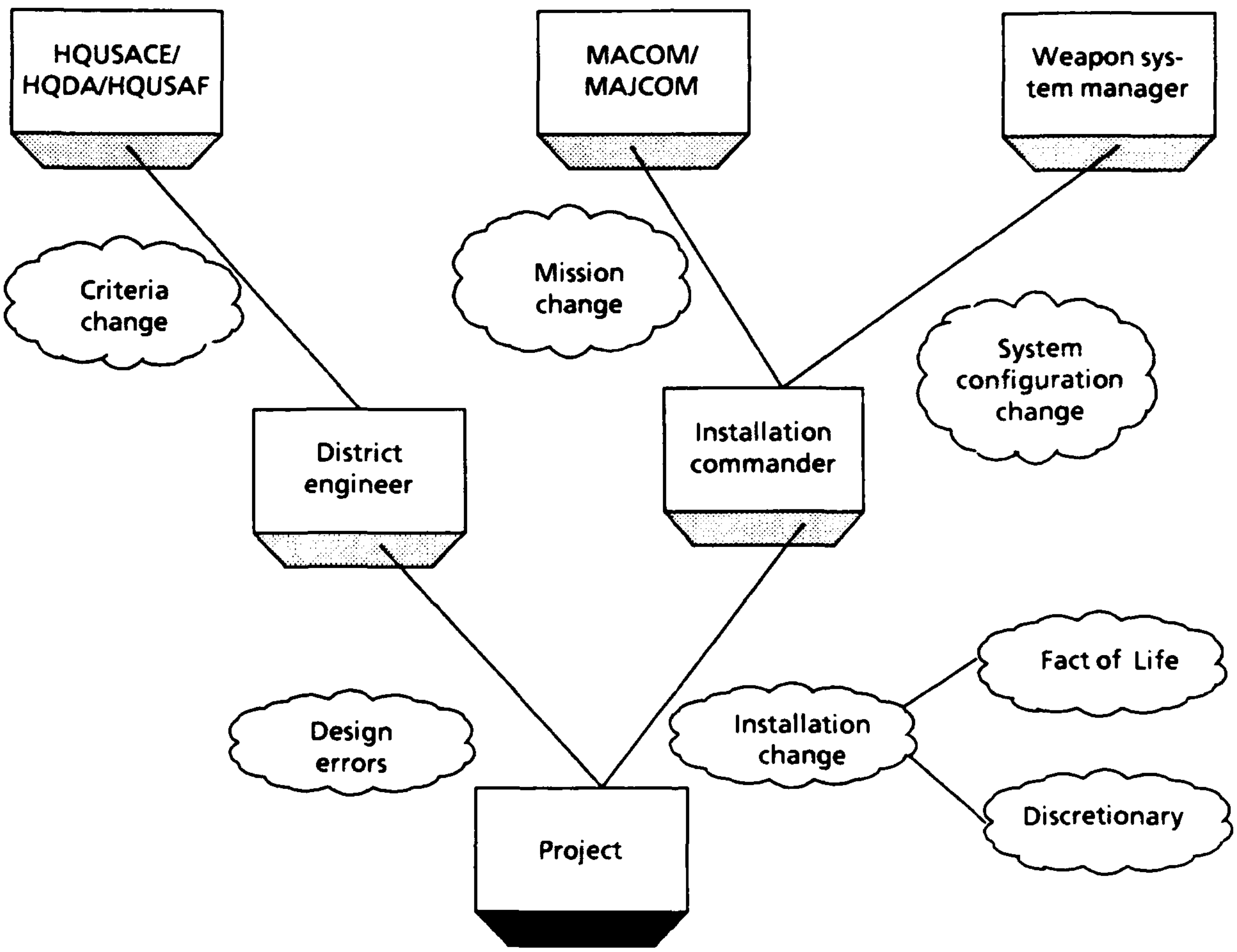

FIG. 3-1. PRIMARY LOST DESIGN CAUSES

system development, the need to replace deteriorated facilities, and mission changes assigned to installations. Weapon systems managers sometimes are unable to anticipate changes in technology that can have major effects on the logistics requirements supporting that system. Such changes can result in changes to facilities even before the design is complete.

Project Planning

Installations believe their planning staffs are overtaxed and have little time available to refine the project plans to mitigate or avoid future changes. An important part of this problem relates to the large number of projects submitted 2 or 3 years in advance of the design year and the relatively few that survive the programming and budgeting processes. Installation planners are not able to devote thorough planning effort to projects that have a limited chance of surviving the budget cuts. Moreover, tl.e more time that a project languishes from its planning stage through design authorization, the more likely that criteria, scope, and sites will be changed.

The prescribed document to ensure adequate Army project planning, known as the *Project Development Brochure* (PDB), has been severely neglected in recent years. Army Regulation (AR) 415-15 requires that the PDB be prepared before preparing DD Form 1391, the form required for all projects submitted to Congress in the President's Budget. Some believe it has become common practice to prepare the PDB after preparing the DD Form 1391, but a PDB prepared after the fact is of little value. We believe that project planning has become weakened and is a major factor in lost design.

Customer Satisfaction

Another factor contributing to lost design is a tendency by customers and design agents to give the customers as much freedom as possible in making changes to the design. While some changes are extremely important, others are not. Changes arising from different mission requirements, different weapon systems configuration, life-safety issues, or unknown site conditions are essential and must be incorporated into the design irrespective of design cost. Although many of these changes might be traced back to inadequate planning at some level, to ignore them could be foolhardy.

The relatively small cost of design contrasted with the life-cycle cost of a permanent facility argues for the design to be the best product possible.

Many changes are not essential. One of the more common discretionary types of change occurs following a change of command at the installation or customer level. New commanders are prone to make changes based on personal preference, rather than on informed professional judgment. The staffs of both the customer and the design agent, desiring to provide a satisfactory product, are likely to accede to the commander's desires. A commander who senses that project planning is weak is more likely to make changes to a completed design.

The Department of the Army (DA) uses a high-level committee referred to as the Corporate Group to help instill discipline in design changes. Its function is to "manage user-originated changes within scope during the final design and construction phases of Military Construction, Army (MCA) funded projects."[2] This three-member body consists of representatives of the MACOM that programmed the project; Headquarters, USACE; and the appropriate USACE division. By assigning a high-level group to review changes, the Army hopes to minimize user changes and approve only changes that serve the best interest of the Army. Unfortunately, a group with this charter cannot substitute for sound project planning; it can only respond to changes proposed when planning has failed.

Balancing customer satisfaction and efficient design management requires careful judgment. The task force believes that a financial incentive could help to moderate the number of discretionary changes made by the customer. If the customer could be required to pay for such changes out of local funds, the incidence of change would probably be reduced. Even though the use of O&M funds to offset additional MILCON design costs would require concurrence of the MILCON oversight congressional committees, it should be considered. Air Force projects are somewhat self-policing in this regard since the customer now maintains control over its MILCON design funds.

Design Certification

The task force reviewed current Navy procedures that require all MILCON projects to be certified, ready for design (CRD). The CRD process differs significantly

[2]Army Regulation 715-15, Military Construction Program Development and Execution, Appendix D, paragraph D-1.

from Army procedures by using MILCON funds to review project plans and evaluate the quality of the project data before the projects are authorized for design. The Navy is careful to point out that this review would otherwise have to be conducted by an A-E firm (or in-house design team) after initiating design, and therefore, it is an appropriate use of MILCON P&D funds. The process cannot be used to correct problems found in the planning documents; MILCON rules require that planning be done by the installations using their own sources of funds.

The CRD process proceeds in July following the spring submission of the Navy's DD Form 1391s for the following year design cycle. The NAVFAC Engineering Field Division (EFD), Navy's counterpart to the USACE district/division, must have the CRDs prepared by October in order to be authorized to proceed with concept designs at the beginning of the fiscal year. Project plans found to be deficient are returned to the major claimant (Navy counterpart to MACOM/MAJCOM) for correction or updating. Designs cannot proceed unless certification is received by NAVFAC headquarters.

Navy officials believe the CRD process has significantly improved the quality of project planning and reduced the number of changes requested by customers. More important, it has focused the design agent's professional attention on project planning well before the designs have begun. In some cases, A-E firms selected for the concept designs are given an early opportunity by preparing CRDs to resolve questions and clarify project plans before beginning the actual design.

CONCLUSIONS

In summary, we reached the following major conclusions derived from our analysis of lost design:

- Lost design data are not accurately reported.
- A clear definition of the terms *lost design* and *design breakage* needs to be established for consistency in reporting lost design.
- With a revised set of reason codes and a standard report format, field offices will be able to report more accurate and consistent lost design information.
- User- or customer-generated changes account for 70 to 90 percent of all changes to designs resulting in lost design.
- A primary cause of user changes stems from inadequate planning during project development. Many customers no longer use the PDB as a means to

plan projects. In almost all cases, the front-end planning needs to be more thorough.

- A means to charge customers for lost design costs arising from users' discretionary changes would probably help to reduce nonessential lost design.
- A CRD process, similar to that of the Navy, which uses P&D funds to verify the quality and accuracy of planning and cost information before authorizing design, could help to stimulate sound planning.
- An engineer regulation (ER) could clarify the guidance needed to improve the reporting accuracy of lost design. Appendix G is a recommended ER for lost design.

CHAPTER 4

LARGE AND COMPLEX PROJECTS

The task force was asked to review P&D services and costs for large and complex projects. The USACE is concerned that P&D for such projects is difficult to manage and requires a large and, perhaps, disproportionate amount of effort, time, and management attention. We define large and complex projects as those at or above $100 million in construction value or those of such technical complexity that extraordinary project oversight would be needed. Examples of complex projects would be projects with complex production or process systems, sophisticated electronic systems, and state-of-the-art environmental control systems. Medical facilities projects were excluded from this review because of their unique management oversite required by the Assistant Secretary of Defense (Health Affairs).

The methodology for examining the special projects task was to review USACE and non-Federal agency/private-sector projects and to develop comparisons and evaluate methods that could improve USACE management of its large and complex projects. The task force obtained planning and design data from nine representative USACE projects. The LMI staff visited five projects to obtain planning and design data from projects managed by non-Federal agencies and commercial firms.

LARGE/COMPLEX USACE PROJECTS

Nine USACE projects were submitted to the task force for review (see Table 4-1). They range from the $7.6 million Hydrant Fuel System at Griffiss Air Force Base (AFB), N.Y., to the $226 million Large Rocket Test Facility at the Engineering and Development Center, Arnold AFB, Tenn. Most of the projects chosen are needed to satisfy complex Air Force facility requirements. One of the projects was managed as a classified project requiring special clearances for the A-E firm and its staff. Most of the projects required sophisticated communications, security, and data processing capabilities, and some required support for state-of-the-art technical processes. A project required special consideration for its comprehensive interior design (CID), which with customer changes, accounted for

more than 1.6 percent of the total project program amount (PA). Projects involving additions to existing facilities also required extensive design services in surveying existing conditions. A few of these projects required "fast tracking" to meet tight deadlines, and one project required extensive coordination to integrate Government-furnished equipment with both the design and construction phases of the project.[1]

TABLE 4-1

LARGE/COMPLEX USACE PROJECTS

Project description	Program year	PA ($ million)
Guided Weapons and Evaluation Facility, Eglin AFB, FL	88	20.0
Solid Motor Assembly Building, Cape Canaveral, FL	90	89.0
Large Rocket Text Facility, Arnold AFB, TN	89	226.0
NORAD and Space Command Headquarters, Peterson AFB, CO	85	19.0
Hydrant Fuel System, Griffiss AFB, NY	90	7.6
ADAL Aerospace Data Facility, Buckley ANGB, CO	88	15.5
B-2 Test Support Facility, Edwards AFB, CA	85/86	85.0
Consolidated Maintenance Facility, Tooele AD, UT	89	37.0
Standby Power Plant, Vandenberg, AFB, CA	85	15.9

Note: NORAD = North American Air Defense; ADAL = additions and alterations; AD = ammunition depot.

The task force was asked to develop costs of design and particularly the costs of separate design services, where those costs could be determined. We found that the information available is quite limited following actual cost accounting procedures. Most districts cannot capture in-house costs by separate design services. For those services procured from an A-E firm, the district staffs were able to allocate costs

[1]"Fast tracking" is jargon that means a project receives special handling throughout each phase of design and construction.

based on the breakdown of services delineated in the A-E schedule of prices. The data were helpful in evaluating the range of services provided for the more complex projects and gave a reasonable yardstick for measuring costs.

Overall design costs for these nine projects averaged 8.0 percent of the PA, as displayed in Appendix H. For projects in the cost range above $10 million, this rate was about 1 percent higher than the historic average of 7.0 percent for all similar projects in the same size category.[2]

The range of design services required for these projects was more extensive than would be expected for typical MILCON projects. Special seismic and utility studies, pile vibration tests, life-cycle studies, three-dimensional models, environmental permit applications, and CIDs are examples of services that were required for these complex projects. In some cases special services, such as environmental permits and CIDs, required from 1 to 2 percent of the total PA. Special design requirements can consume 20 to 30 percent of the entire planning and design budget. A summary of the kinds of P&D services included in our sample of nine projects is also provided in Appendix H.

We excluded construction phase design services from the projects summaries since those services are paid for from construction funds rather than P&D funds. The amount of engineering and design services used during construction was extensive and includes such items as reviewing shop drawings and providing Title II inspection services. In at least one case, the cost of the engineering and design services during construction equated to about one-third the cost of the P&D services.

The task force asked its members to query the customers who had been involved with the design and construction of these projects to determine whether changes to the design program and process should have been made. In summary, we paraphrase some of the more critical comments received.

- Better coordination and integration of the facility user's equipment and facility designs would have reduced the large number of changes. The two should have been done in sequence and phased as a team approach, rather than designed in parallel.

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[2]Report AR001R1, *Military Construction Planning and Design Funding Requirements*, James L. Hathaway, Eric M. Small, and Jeffrey Hawkins, November 1990.

- Acquisition strategy planned early and the use of research, development, test and evaluation (RDT&E) funds to accomplish both design and construction allowed full integration and greatly helped this project completion schedule.

- If the functional requirements were defined better before concept design began, this project would have had fewer changes.

- This project required far greater emphasis on the environmental permit requirements. It should have been constructed as a design/build project that required the contractor to solve all environmental issues.

- The long delay from project inception to the start of design and the inadequate site investigation led to high design cost and multiple change orders on this facility addition/renovation project. Integration of USACE-designed landscaping and site work with the A-E building design did not go smoothly.

- Fees for the A-E firm were held down so tightly during negotiations that its performance was adversely affected, primarily in meeting the schedule. Conducting some studies in parallel with design led to redesigns after the studies were completed.

- The USACE and its customer, together with the customer's contractor/operator, had an effective partnering relationship during the course of this project; however, the A-E firm was not made a part of that same partnering effort. That was a mistake.

- Selection of the equipment manufacturer who submitted the lowest bid for a critical portion of this project led to severe schedule and quality problems. A qualified supplier at a higher price would have been far preferable.

- Design funds would have been better used if less had been spent on interior design and more on identifying the technical requirements of the user.

- Some features in a project as complex as this one should not be designed until construction is well underway so that we can capture late criteria changes and requirements. Examples are interior layouts, central security system, signage, local area networks, and systems furniture.

- The A-E firm should be on site during much of the construction phase to speed up shop drawing turnaround time and respond to design questions.

- The Corps charges too much for its services.

Greater levels of uncertainty and technical sophistication were also encountered with these large and complex projects. Because of their visibility, these nine projects received high levels of scrutiny, additional reviews, and expanded

coordination with diverse groups. Based on previous research we expected these large projects to require a lower P&D rate than smaller projects. However, as projects become more complex, we find that expectation is not warranted. The higher level of design services and increased complexity can more than offset the lower P&D rate that otherwise would be realized because of project size.

NONFEDERAL LARGE AND COMPLEX PROJECTS

The LMI staff visited five major projects to compare methods that other agencies and the private sector use to manage their design programs and projects and their associated costs. Table 4-2 lists those five projects and their program amounts.

TABLE 4-2

NONFEDERAL LARGE AND COMPLEX PROJECTS

Project description	Program amount ($ million)
John F. Kennedy Airport Redevelopment Program; Port Authority of New York and New Jersey	3,200
Milwaukee Water Pollution Abatement Program; Greater Milwaukee Water and Sewer District, WI	2,000
Port Everglades Expressway, Broward County, FL	1,200
Hyperion Energy Recovery System; SE Technologies, Bridgeville, PA	43
Los Angeles County Light Rail System (Blue, Green, and Red Lines); Rail Construction Corporation, CA	4,660

Only a few Government organizations or enterprises would ever have an opportunity to become involved or manage projects as large and complex as those we visited. Even the Hyperion Energy Recovery System, while comparatively small in dollar value, is a segment of the huge Los Angeles waste water treatment facility and involves state-of-the-art technology in its sludge combustion process. DoD programs such as the Saudi construction program, Fort Drum development, Diego Garcia, British Indian Ocean Territory (BIOT), and the space launch complex at Vandenberg AFB compare in size to these non-Federal projects, but such DoD projects are not considered routine for USACE or other Federal agencies. Many of the observations

we made while visiting these projects, nevertheless, help to make valid comparisons with large and complex USACE projects.

A brief summary of each project is presented in Appendix I. The following discussion of the owner/client relationship; A-E firm contract design and construction integration; environmental, real estate, and community issues; and design services and costs describes the more relevant findings from our visits with the project representatives.

Owner Representation

None of the projects selected is considered a purely private-sector project. Few commercial interests construct facilities on a scale matching the scope of these projects. An automobile or aircraft manufacturing plant or a major amusement park are notable exceptions. In our sample projects, the owners are local authorities, municipalities, or state governments. But few agencies such as local governments are staffed to oversee and manage large and complex projects of this scale. They must acquire the services of construction, program, and project management. USACE, on the other hand, functions as the owner's sole representative for its DoD customer's large and complex projects.

The more the agencies bring private firms into their organizations to assume management roles, the greater the risk that the firms may not always act in the best interest of the owner. The fear of conflict of interest often overshadows the desire to use an outside firm, and some agencies avoid using outside firms except as a last resort. Other agencies view the outside construction manager as the only possible solution to a vexing problem of in-house staff and skill shortages, clearly outweighing any concern over conflict of interest. The typical agency about to embark on a large and complex project will normally avoid temporary staff expansion in favor of hiring a firm specializing in construction management (CM). It believes that at project completion a CM contract can be terminated much easier than in-house employees can be released. Additionally, CM firms offer a full range of services, and therefore, training of new employees is not a factor. We found most owners include some of their staff as members of the CM team to ensure a measure of checks and balances and continuity for the project after the CM firm has completed its responsibilities.

Most of our discussions were held with the members of CM firms hired to represent the agencies that owned these major projects. We found those firms to be

very conscious of the role they fulfill for the owner, striving to obtain high quality at the lowest price and meeting completion deadlines. The typical role for CM firms includes full oversight of the design and construction process. The market for CM firms appears to be expanding.[3] An increasing number of owners are turning to CM firms because they need to gain tighter control over construction and design budgets, driven in part by tight economic imperatives. Additionally, the General Services Administration (GSA) now uses CM firms for its building projects exceeding $10 million in construction value.

Architect-Engineer Contracts

Project owners generally follow a process for hiring A-Es very similar to the procedures under the Brooks Act.[4] That legislation requires, inter alia, that A-E firms be selected for Federal projects on the basis of competence and qualification for the type of professional services required. Price becomes a consideration during negotiations but not an important factor for selection. Many of the CM firms for major projects are hired under the same procedure, and, in turn, they assist the owner in hiring A-E firms for the design projects using a qualification-based selection (QBS) process. Generally the owner and CM form a team to execute each phase of the acquisition process: scope definition, announcement, qualifications review, fee estimate, negotiation, and contract administration. Most agencies reserve the final selection of the A-E firm to their own senior directors, boards, or councils.

We found that AIA Document B-141 provides the framework for the majority of non-Federal A-E contracts in terms of defining the scope of work and range of services. That document is recognized as an industry standard and contains many similarities to A-E contracts used by DoD. One notable difference between the AIA Document B-141 list of basic services and that of A-E firms under contract with USACE is the submission of design drawings in three separate phases – schematic design, design development, and construction documents. The primary difference is in the schematic design phase submission, which takes place at about the 10 percent stage of design and establishes an early understanding between the owner and the A-E firm in verifying the owner's requirements and cost limitations. The USACE

[3]"Special Report on the Top 100 CM Firms," *Engineering News Record*, July 1-8, 1991.

[4]The Brooks Act, Public Law 92-582 (40 U.S.C.§541, et seq.), became effective in 1972.

requires submission of designs at the 10 percent stage for Air Force and medical projects only.

Large and complex projects generally are made up of many smaller projects. To accommodate the many diverse phases and kinds of work required, designs are similarly divided into a series of smaller contracts. Each successful A-E firm knows that its selection for future contracts will depend largely upon its performance on the current contract, thus providing a powerful stimulus to produce quality work on time and within budget.

The CM firm/owner team generally reviews all plans and specifications prepared by the A-E firm. The depth of that review varies widely, depending on the experience of the firm performing the design, past practice of the agency, and complexity of the design itself. In most cases reviews are limited to ensuring that the project meets the basic requirements set forth in the scope, with heavy emphasis on project constructability. We found most owners trust the judgment of their CM firm in conducting the reviews and tend to participate more actively in the early schematic phase.

The CM firms expressed concern that the growing trend toward hiring A-E firms based on price competition in the commercial sector could threaten the QBS process for Government agencies. Austere economic conditions could accelerate movement in that direction, but, the large number of agencies with QBS firmly embedded in their A-E hiring process are likely to limit the spread of competition-based A-E contracts to the public sector.

Design Construction Integration

Possibly the most significant finding with regard to the non-Federal projects was the full integration of design and construction, which contrasts with the typical DoD project. In the DoD projects, design and construction funds are obtained separately from Congress and the management of design and construction is overseen by separate internal organizations in each USACE district office. For routine MILCON projects this arrangement has served the Government adequately; however, for large and complex projects the design and construction processes must be firmly integrated. We note that USACE addresses this management concept in its life-cycle management program.

We see four compelling arguments for integrating the design and construction phases and their funds under a single manager:

- Construction funds could be traded off for design funds to improve designs before encountering major construction costs.
- Communications would be strengthened between the designer and the builder.
- Changes could be made easier when unforeseen conditions or requirements occur during construction.
- Feedback to the owner and designer would be improved and could serve as part of lessons learned for future projects.

Most non-Federal agencies seek funds for major projects as a complete package, i.e., design, construction, and project/contract management and administration. The percentage of funds estimated for design may be identified in documents supporting funding requirements, but seldom are restrictions placed on how the funds are to be used between design and construction. That procedure gives program and project managers the flexibility to apply funds as needed to obtain the completed project. If, for example, spending another $50,000 in design will save $1 million in construction costs, that decision can quickly be made by the construction manager or the PM without having to seek justification or approval from someone within the owner's hierarchy.

We sensed a strong need for team building within these projects. No adversarial relationships among the owner, CM firm, A-E firm, and construction contractor were noticeable. It appeared that mutual interdependence for information and recognition of each others' responsibilities and needs instilled a strong sense of partnering. When the contractor encountered questions about the plans and specifications, direct communication with the A-E firm was encouraged. Owners and construction managers became involved only when differences could not be resolved bilaterally or changes of a significant nature became necessary. Most A-E firms were required to provide a limited amount of on-site services or maintain some presence during construction. Those services and presence helped the PM and contractor and also provided valuable constructability feedback to the A-E firm for improving future designs.

Environmental, Real Estate, and Community Issues

Non-Federal projects take environmental issues in stride as a way of doing business. In the projects we assessed, most environmental issues were resolved before the CM or A-E firms began their work. Some projects, such as the Light Rail Lines in Los Angeles, encountered almost no opposition from environmental groups since the availability of mass transit in Los Angeles will help to reduce severe automobile pollution. Destruction of wetlands required by the Port Everglades Expressway project was mitigated by the construction of artificial wetlands. The Hyperion and Milwaukee waste water pollution control projects were each funded to reduce environmental contamination and thus generated only minor environmental issues.

The Port Everglades project required a major real estate acquisition (estimated at $486 million or 40 percent of the PA), which because of its criticality to construction progress, was turned over to the CM firm for management. This assumption by the CM firm of a function traditionally reserved for the Florida Department of Transportation (FDOT), led to some difficulties between local FDOT officials, Federal Highway Administration representatives, and the CM firm. At the bottom line, however, progress was stepped up and the project was completed ahead of schedule. Full integration of this major project element (real estate acquisition) with the design and construction became a centerpiece for meeting time and cost requirements.

Community interaction has also been an important element for executing these major projects. In the case of the Los Angeles Light Rail Line project, as many as 90 separate jurisdictions will be affected by construction before the program is completed. Design coordination and review has focused on the rail stations, and the Rail Construction Corporation (RCC) seeks to keep the public well informed of progress and the schedule for the new lines and stations to be opened. The Port Everglades I-595 PM operated an on-site community involvement program office that responded to public inquiries and showed citizens how the expressway was to be phased and when traffic would be rerouted to accommodate construction. The owner and construction manager believe this extra effort was largely successful in dampening the number of complaints and increasing the tolerance level of citizens

during construction. Similar community information programs were instituted at the other major project sites.

Design Services and Costs

We experienced more difficulty in obtaining data on the range and types of design services and their costs for our non-Federal sample projects than we did for the USACE projects. The reason is that owners and CM firms are focused on the total cost of the project, which is driven by the construction cost. Contracts for engineering and design services tend to be negotiated at bottom line costs, based on man-hours, sheets of drawings, and design cost per square foot, rather than on individual services. Accounting practices for each A-E firm vary widely, particularly in the items that are considered direct project costs and those that are considered overhead. Those differences make it difficult to determine actual costs of individual services. Similarly, owners define services using different terms. For example, predesign, preliminary engineering, and planning services can each describe the same service or entirely different ones. If a project requires services in addition to the basic design services as defined by AIA Document B-141, separate fees are usually identified for those services. Such additional services generally fall into the categories of predesign studies and requirements, administrative (i.e., extra travel, express mail, and reproduction), special presentations and reviews, and construction support.

By following the standard design phases set forth in AIA Document B-141, owners and their A-E firms reach a mutual understanding during the schematic design phase. Based on that agreement, the A-E firm develops schematic drawings and a preliminary cost estimate. The schematic phase and the design development phase together result in a document similar to that produced in the USACE concept phase; it represents approximately 35 percent of the design. Large and complex projects inherently require additional submissions of design documentation. We found one agency requiring submissions at the 40, 90, and 100 percent stages; another required submissions at the 30, 60, 85, and 100 percent stages. A point often made was that formal reviews and submissions should not become the sole means of communication between the A-E firm and the owner or the owner's representative. Frequent informal discussion helps to avoid misunderstanding and build confidence in each party. Any concern that such informal discussions could lead to scope

changes in the A-E contract is totally overshadowed by the need for frequent and effective com: ication.

Predesign services include site or master planning, special studies, and developing alternatives. They are considered additional services and, if required, must be added to the basic list of design services for the project. Similarly, detailed and continuous inspection of the work during construction is not part of the contract for basic design services.

Another additional service deals with the provision of promotional materials, such as models, renderings, or brochures. The requirement for such services varies widely. Because most of the work on the Milwaukee waste water project was underground, a few artists' renderings were adequate for its promotional needs. In contrast, the I-595 project in Broward County invested over $70,000 in a scale model, which became the centerpiece of its community relations program.

Regarding site visits by the A-E firm personnel, AIA Document B-141 specifies that they will conduct site visits "to become generally familiar with the progress and quality of the work completed and to determine in general if the work is being performed in a manner indicating that the work when completed will be in accordance with the contract documents." In other words, industry practice is for A-E firms to be present occasionally during construction. The sample projects we visited generally required the A-E personnel to be on site enough to be sure the project was being completed as required. DoD does not have a similar requirement unless a problem is encountered in which the A-E personnel may be needed or unless full-time inspection services are required for a portion or all of the construction work.

Because the scope of A-E services differed greatly between projects, the cost data for A-E services does not permit a consistent comparison. A simple calculation of the costs provided for engineering and design versus the overall program costs ranged from 4.5 percent for the I-595 project to 11.5 percent for the Hyperion project. The other three projects averaged about 8 percent. We had expected the I-595 highway/bridge project to have lower design costs because horizontal construction is relatively less costly to design. Similarly, we expected the high-technology Hyperion energy recovery project to be at the higher end of the cost scale, particularly with its heavy requirement for on-site engineering testing and operation support.

Additional Large and Complex Project Characteristics

Large and complex projects are often subdivided into numerous smaller projects and completed in phases over a number of years. Care must be exercised to provide linkage between each of the smaller projects. Schedule coordination is paramount. The PM must consider the construction sequencing of work whereby use of common infrastructure and construction staging areas may be required.

Life-cycle cost issues can become magnified in a large project. If a system of controls, for example, will be repeated during later phases of a project, the designer must take care to specify common equipment so that the owner can operate an effective maintenance program. If this requires the procurement of proprietary equipment or items in subsequent phases, careful acquisition planning is required. If the equipment is sophisticated or if it requires special training, project management may purchase installation and operation services with the equipment.

Many complex projects require long lead times for specialized equipment. The lead time issue becomes magnified for projects being constructed overseas. Designers must be careful to specify equipment and materials that are consistent with meeting construction deadlines. If materials or equipment are to be supplied by the owner, extraordinary coordination is required, and that coordination includes double checking of specifications, procurement documents, storage and delivery plans, and connection and installation requirements. The project/design management team must not fail in this crucial area.

CONCLUSIONS

On the basis of our review of P&D services and costs for large and complex projects, we reached the following conclusions:

- Total project cost should be a more important issue than either the individual design or construction costs. Design funds should be used to leverage construction costs when necessary. Restrictive rules on funding source should be a secondary issue.
- Large and complex projects usually require extraordinary, albeit temporary, organizations to oversee their management. Such organizations can be developed using a mixture of in-house staff and contractor expertise. They improve communication with the owner, minimize conflicts of interest, and can be quickly assembled and disassembled.

- A strong partnering relationship between the client, USACE district office, and A-E firm is essential to ensure thorough understanding of the client's processes, special equipment, other requirements, and the client's expectations. That relationship should be established as soon as each party becomes involved.

- Partnering should be maintained through the construction phase as each construction contractor arrives on the scene. Full involvement of the owner, PM, A-E firm, and contractor helps to improve communication, and promotes teamwork to solve problems, and eliminates adversarial relationships.

- A carefully developed acquisition strategy will effectively balance constructability with life-cycle considerations, such as maintainability and operability.

- Design services in the private sector that are consistent with AIA Document B-141 definitions help in negotiating A-E fees on a consistent basis. Within the USACE, a standard design services menu (which after negotiation with the customer becomes the basis for a design contract) would help in negotiating A-E fees and tracking services and costs.

CHAPTER 5

P&D RESOURCE ALLOCATION

The USACE needs to be responsive to budgetary pressures and to remain a competitive source for the design of military construction projects. To execute the P&D program successfully, its managers must forecast manpower and funding requirements and allocate available resources to the divisions and districts. It needs a method to perform those functions quickly and accurately and to analyze the effect that changes to the military program have on its manpower and funding requirements. USACE managers also need to be able to generate accurate P&D budget estimates for specific projects. To that end, we have developed two microcomputer-based models for determining P&D funding requirements:

- CERAMMS[1] P&D Model Enhancement
- P&D Estimating Model.

We have also developed a microcomputer-based model for estimating P&D workload capacity given specified levels of engineering staffing.

OVERVIEW OF CERAMMS

The CERAMMS model is an automated means for forecasting military manpower requirements. It is a management tool that USACE decision makers can use to forecast staffing requirements and effectively manage their manpower resources. It is designed so that users can easily update input variables and assumptions and check the effect on manpower levels.

The CERAMMS model addresses the two primary USACE management needs – forecasting requirements and allocating resources. Figure 5-1 illustrates the main components of the model and how they are organized. Consistency within the model is maintained through the use of common input files, which ensure that the same assumptions and policies that drive manpower requirements are used to

[1]LMI Report AR603R1, *Corps of Engineers Resource and Military Manpower System,* William B. Moore, Robert W. Salthouse, Robert A. Hutchinson, and Robert L. Crosslin, May 1987.

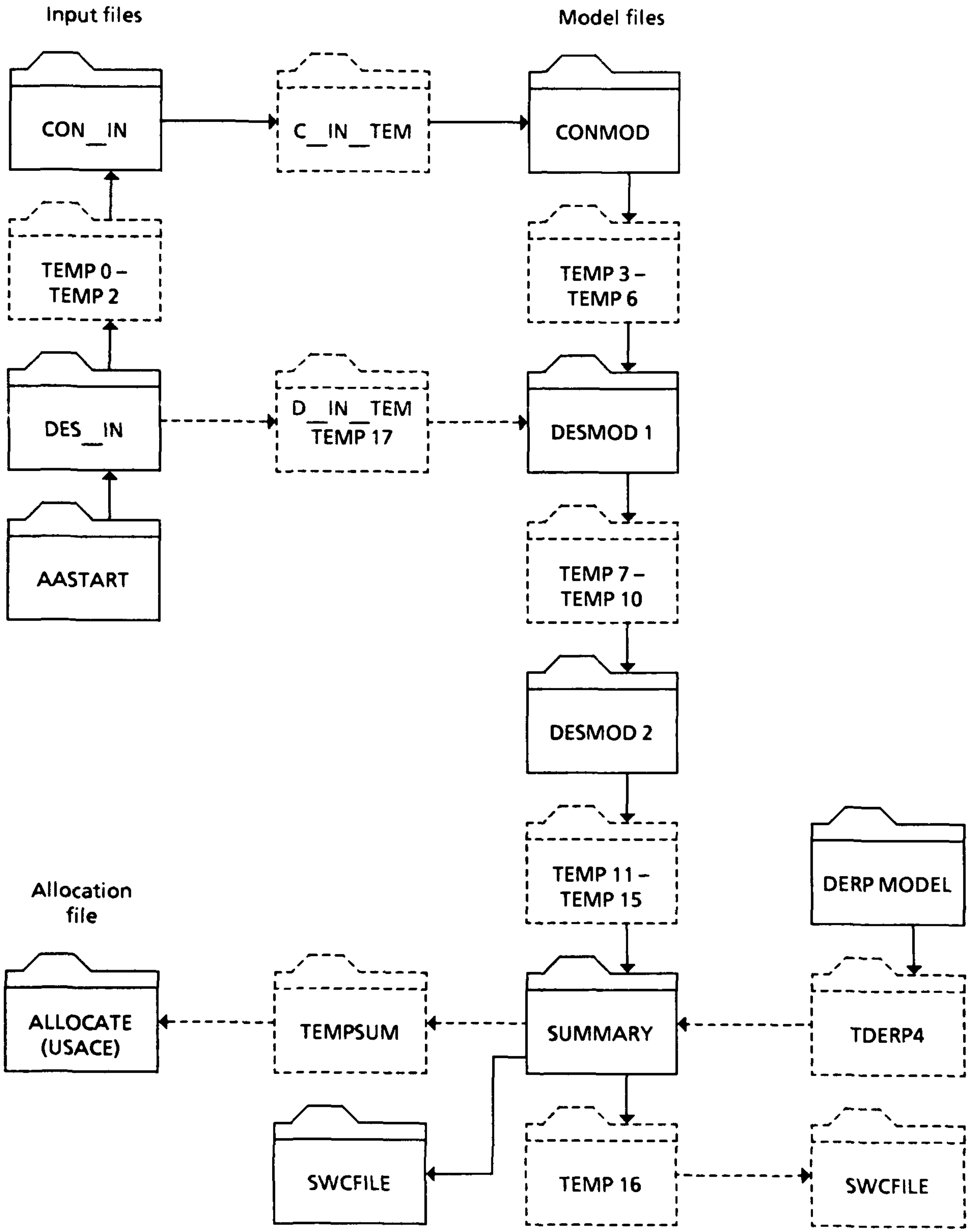


FIG. 5-1. ORGANIZATION OF CERAMMS COMPONENTS

(Input files, model files, and data transfer files)

determine P&D and Supervision and Administration (S&A)[2] funding requirements. We believe that the interrelated modules within CERAMMS provide an effective mechanism for developing manpower requirements, establishing P&D and S&A targets, and then allocating available resources.

Both engineering and construction workload inputs are measured by the estimated cost of construction (ECC), which is calculated by subtracting contingency costs, engineering-during-construction costs, and S&A expenses from the annual PA. We refer to this workload measure as the adjusted PA. The more important workload measure is the spread workload, which is a detailed apportionment of the adjusted PA to the year or years in which the engineering and construction services are performed rather than the year in which the project is appropriated.

THE PLANNING AND DESIGN MODEL

A natural linkage exists between the manpower required to execute the engineering program and the P&D requirements. The fiscal resources needed to support the manpower used to execute USACE's military engineering comes from P&D funds. The P&D funds allocated to a district should be directly related to the amount of design effort a district expects to expend. If such a linkage is not made, a district could be placed in the position of being allocated sufficient manpower but not being able to pay salaries and associated costs or, similarly, having sufficient funds but not enough allocated manpower. P&D funds are linked to manpower through anticipated workload in CERAMMS.

The CERAMMS facilitates the linkage by using a methodology that employs the same workload data to determine P&D targets and calculate manpower requirements. Further consistency is achieved by applying the same set of rules for all districts and divisions to determine manpower and funding requirements.

The outputs from CERAMMS can be used to establish targets and evaluate past performance. Effective management indicators can be developed by combining the outputs from the P&D model with those of other available models. As an example, estimates of engineering placement are model inputs; the USACE can then use those estimates in conjunction with the estimates for P&D funds needed and in that way, develop the cost per dollar of project for providing design services. Past performance

[2]S&A construction funds are set aside for each MILCON project to supervise and administer the construction contract. The S&A rate at present is 6 percent of the construction cost.

can also be evaluated by comparing historical expenditures for P&D to CERAMMS estimates. Such indicators can be used to evaluate and manage the execution of the USACE military design program.

The P&D model is divided into two parts in CERAMMS. The first part, which is resident in the engineering module of the manpower forecasting model, calculates the P&D funding that would be required for the forecasted design placement. The funding requirement is determined by applying rates developed from an analysis of historical planning and design costs to the forecasted design placement. The funding requirement is calculated for each fund type and for the total design program. Initial design targets for P&D costs can be established by dividing the total P&D funds required by the forecasted design placement.

The second part of the P&D model, which is resident in the summary module, establishes final P&D targets after considering certain management inputs. The management inputs considered are any special conditions that may affect the P&D funding requirement within a district.

CERAMMS Planning and Design Model Update

The CERAMMS Version 5.0 contains new engineering staffing factors, new engineering spreading factors, and new average engineering project sizes. All those parameters are based on statistical analysis of historical data. Appendix J describes the statistical analysis used to develop the model coefficients. Average engineering project sizes are presented in Table 5-1.

A recent study by the Project Management Division prompted the creation of a P&D management module. As a result, CERAMMS has revised procedures for forecasting P&D funding requirements. The model also displays funding requirements, placement estimates, manpower requirements, and targets in the output file.

The CERAMMS Version 5.0 model contains a number of P&D management functions. Among those features are some that existed in previous versions of CERAMMS such as estimates of design staffing requirements and design placement estimates and new features such as P&D funding requirements based on new forecasting algorithms.

TABLE 5-1

AVERAGE ENGINEERING PROJECT SIZES

Fund type	Construction cost ($000)	
	Less than $5M	Greater than $5M
Military Construction, Army	1,670	10,780
Military Construction, Army Reserve	1,670	10,780
Military Construction, Air Force	1,598	8,800
Military Construction, Navy and Marine Corps	998	13,710
Military Construction, Other	1,800	N/A
Operations & Maintenance, Army	323	N/A
Operations & Maintenance, Air Force	482	N/A
Family Housing, Army	1,396	N/A
Family Housing, Air Force	1,830	N/A
Production Base Support	1,600	N/A
Host Nation Support	3,000	N/A
Foreign Military Sales	3,333	N/A
Base Realignment and Closure, Army	3,870	N/A
Base Realignment and Closure, Air Force	2,780	N/A

Note: N/A = not applicable.

Planning and Design Model Inputs

The P&D model uses the same program inputs to calculate both manpower and funding requirements. The design program is input along with assumptions about the program such as the amount of in-house design expected for each type of customer, the average fully burdened engineering salary, the percentage of the program amount that is expected to become design workload, and the number of man-hours available per man-year. To take full advantage of the model, the project size distribution by customer can also be input. That information is needed since the design funding algorithms differentiate among large, medium, and small projects within each fund type. The model will use historic project size distributions if no new information is input.

Planning and Design Model Outputs

The following outputs are produced by CERAMMS and are available through the P&D model:

- Estimate of design placement by fund type by year
- Estimate of manpower staffing requirements by fund type by year
- Estimate of P&D funding requirements by fund type by year divided into A-E, in-house, and total requirements.

All design-related outputs except for the breakdown of engineering manpower by standard work center codes (SWCCs) are available within the P&D model. Use of CERAMMS to estimate P&D resource requirements is explained in detail in LMI Report CE006TR1, *CERAMMS, Corps of Engineers Resource and Military Manpower System, Version 5.0 User's Guide*, April 1991.

PLANNING AND DESIGN ESTIMATING MODEL

The P&D estimating model is an automated management tool with which project managers can estimate P&D budgets for specific projects. It was designed to help PMs assist customers in determining the level and cost of P&D services needed for each project. Customers sometimes require services in addition to those typically provided by USACE offices, and other times USACE provides services beyond those necessary for getting the job done. Either case can lead to a customer being overcharged or undercharged for the job. The P&D estimating model enables the design agent and the customer to select the appropriate level of P&D services and to develop a budget estimate for the selected services.

Engineering and Design Services

The scope of P&D can vary dramatically. Therefore, when estimating the costs to be billed to customers, it is essential to know what P&D services will be provided for a specific project. Table 5-2 shows the complete list of P&D services that can be provided during any given project. (Note: The model is based on the menu of engineering and design services presented in Table 2-1.)

Each service shown in Table 5-2 adds a different proportion to the total cost of a P&D project. By identifying the relative cost for each service, the USACE can compare the total costs of individual projects when the levels of service vary.

TABLE 5-2

PLANNING AND DESIGN SERVICES

Engineering and design services	Typical cost	Proj. spec. cost	Budget est.
1.0 Concept design			
1.1 Design analysis			
1.2 Plans			
1.3 Specifications			
1.4 Cost engineering			
1.5 Life-cycle cost analysis			
1.6 Review			
1.7 Value engineering			
2.0 Final design			
2.1 Design analysis			
2.2 Plans			
2.3 Specifications			
2.4 Cost engineering			
2.5 Life-cycle cost analysis			
2.6 Review			
2.7 Value engineering			
3.0 Additional services			
3.1 Comprehensive interior design			
3.2 Existing condition survey			
3.3 Operating and maintenance support			
3.3.1 Customer training			
3.3.2 Documentation			
3.4 Preconcept design			
3.4.1 Surveys			
3.4.2 GEOTECH investigations			
3.4.3 Single line drawings			
3.5 Project definition			
3.5.1 Scope			
3.5.2 Criteria			
3.5.3 Cost engineering			
3.5.4 Life-cycle cost analysis			
3.6 Promotional material			
3.6.1 Renderings			
3.6.2 Models			
3.7 Other			
3.8 Other			
3.9 Other			
4.0 A-E contract			
4.1 Solicitation			
4.2 Selection			
4.3 Proposal			
4.4 Negotiation			
4.5 Award			
5.0 Construction contract			
5.1 Selection criteria (RFP)			
5.2 Bid evaluation			
5.3 Other technical support			
6.0 Project management			
Total			

Note: RFP = request for proposals.

Unfortunately, neither the private sector nor the USACE currently maintains this level of detail in its cost accounts. However, we can compute the relative weight each service contributes to the total through a technique called the analytic hierarchical process (AHP), which does not rely on quantitative accounting data. To use that technique, the analyst solicits experienced opinions and judgments from a panel of field experts and then quantifies those results using a proven methodology of mathematical algorithms. When the process is complete, AHP assigns relative weights to each of the services – totaling 100 percent – which can then be used to adjust total project costs when the level of services provided is known. Table 5-3 shows the listing of all P&D services with their weights determined by AHP.

Table 5-4 presents an overview of the P&D estimating model. Cost factors for the model are based on historic P&D data. P&D rates decrease as the project's size increases. P&D costs are also dependent on the facility type. The P&D cost estimating model uses different equations for 16 project categories (see Appendix K).

Advance Planning Services

As with engineering and design services, the scope of planning can vary dramatically. Therefore, when estimating the costs to be billed to customers, the estimator must know what advance planning services will be provided for a specific project. Table 5-5 shows the complete list of advance planning services that can be provided during any given project.

The model does not generate typical costs for advance planning services because those costs are unique to each specific project. However, a table for entering the customer's requirements for advance planning is integrated into the model. The advance planning function of the model may be used independently of the engineering and design function.

PLANNING AND DESIGN PLACEMENT MODEL

The P&D placement model is an automated management tool with which USACE managers can estimate the P&D workload capacity for specified levels of engineering staffing. The model is also a useful tool for determining the P&D workload required to support an existing level of engineering staff. Table 5-6 presents an overview of the P&D placement model. The model coefficients are the

TABLE 5-3

P&D DISTRIBUTION FACTORS

Engineering and design services	Construction costs		
	Less than $1M	$1M to $5M	Over $5M
1.0 Concept design	**23.7**	**23.8**	**25.8**
1.1 Design analysis	3.8	3.7	4.3
1.2 Plans	9.8	9.6	11.4
1.3 Specifications	0.5	0.5	0.6
1.4 Cost engineering	2.1	2.1	2.5
1.5 Life-cycle cost analysis	1.5	2.0	2.6
1.6 Review	6.0	4.6	3.5
1.7 Value engineering		1.3	0.9
2.0 Final design	**42.6**	**51.1**	**48.0**
2.1 Design analysis	3.6	5.4	6.0
2.2 Plans	23.0	26.6	25.2
2.3 Specifications	4.3	6.0	7.0
2.4 Cost engineering	3.0	4.2	4.5
2.5 Life-cycle cost analysis	0.9	1.0	1.0
2.6 Review	7.8	6.7	3.1
2.7 Value engineering		1.2	1.2
3.0 Additional services	**14.1**	**13.0**	**15.2**
3.1 Comprehensive interior design			
3.2 Existing condition survey			
3.3 Operating and maintenance support			
3.3.1 Customer training			
3.3.2 Documentation			
3.4 Preconcept design			
3.4.1 Surveys			
3.4.2 GEOTECH investigations			
3.4.3 Single line drawings			
3.5 Project definition			
3.5.1 Scope			
3.5.2 Criteria			
3.5.3 Cost engineering			
3.5.4 Life-cycle cost analysis			
3.6 Promotional material			
3.6.1 Renderings			
3.6.2 Models			
3.7 Other			
3.8 Other			
3.9 Other			
4.0 A-E contract	**6.0**	**3.2**	**2.4**
4.1 Solicitation	0.3	0.1	0.1
4.2 Selection	0.8	0.4	0.3
4.3 Proposal	3.0	1.7	1.3
4.4 Negotiation	1.6	0.9	0.6
4.5 Award	0.3	0.1	0.1
5.0 Construction contract	**3.4**	**2.5**	**3.9**
5.1 Selection criteria (RFP)	0.2	0.2	0.3
5.2 Bid evaluation	0.8	0.5	0.8
5.3 Other technical support	2.4	1.8	2.8
6.0 Project management	**10.2**	**6.4**	**4.7**
Total	100.00	100.00	100.00

Note: RFP = request for proposals.

TABLE 5-4

OVERVIEW OF P&D ESTIMATING MODEL

Inputs	Model factors	Outputs
Project category	P&D services distribution tables	Typical P&D service costs
Program amount	P&D rate curves	Budget estimates
Fiscal year	DoD deflators	

same as those in the CERAMMS model (see Appendix J). Average engineering project sizes are presented in Table 5-7.

Planning and Design Placement Model Inputs

The P&D placement model uses program inputs to calculate both manpower distribution and workload requirements. The engineering staff level is input along with assumptions concerning the design program such as the amount of in-house design expected for each funding category, the number of man-hours available per man-year, and the anticipated program mix by funding category.

Planning and Design Placement Model Outputs

The P&D placement model produces design placement capacity/requirement by funding category and in-house/A-E design placement percentage.

TABLE 5-5

ADVANCE PLANNING SERVICES

Services	Estimated cost
1.0 Master planning 1.1 New plans 1.2 Plan updates 1.3 Short-term component 1.4 Long-term component 1.5 Capital program 2.0 Mobilization master planning 2.1 New plans 2.2 Plan updates 3.0 Studies 3.1 Economic and cost 3.2 Environmental 3.2.1 Environmental assessment 3.2.2 Environmental impact statement 3.2.3 Other environmental studies 3.3 Engineering investigations 3.3.1 Facility requirements 3.3.2 Facility condition 3.3.3 Materials 3.3.4 Utilities 3.3.5 Hydrographic 3.3.6 Flood plain 3.3.7 Transportation 3.3.8 Safety 4.0 Criteria 4.1 Programming factors 4.2 Specifications 4.3 Technical publications 4.4 Standard designs 5.0 Project development 5.1 Scope 5.2 DD Form 1391 5.3 PDB/RAMP 5.4 Design programs (medical proj.) 6.0 Project management 6.1 Project management plan (PMP) 6.2 Liaison and coordination 6.3 Information management 6.4 Schedule management	
Total	

Note: RAMP = Requirements and Management Plan

TABLE 5-6

OVERVIEW OF P&D PLACEMENT MODEL

Inputs	Model factors	Outputs
Fiscal year P&D total manpower Man-hours per man-year Design placement distribution A-E/in-house percentages	CERAMMS manpower factors DoD deflators Average engineering project sizes	Manpower distribution Design placement capacity Design placement percentage

TABLE 5-7

P&D WORKLOAD MODEL

(Average engineering project sizes)

Fund type	Construction cost ($000)
Military Construction, Army	3,556
Military Construction, Army Reserve	2,029
Military Construction, Air Force	2,414
Military Construction, Other	1,883
Operations & Maintenance, Army	359
Operations & Maintenance, Air Force	430
Family Housing, Army	1,602
Family Housing, Air Force	1,102
Production Base Support	1,456
Host Nation Support	4,995
Foreign Military Sales	2,695
Defense Environmental Restoration Program	223

CHAPTER 6

PLANNING AND DESIGN IMPROVEMENT RECOMMENDATIONS

This chapter presents the P&D task force recommendations to improve the methods, procedures, and guidance used in managing USACE P&D.

DESIGN SERVICES

A computer model that could be used to help project managers identify necessary design services and associated costs for customers would be beneficial to USACE district offices. We recommend that USACE review the computer model described in Chapter 5, based on the findings and conclusions regarding P&D services in Chapter 2, and make it available to all project and design management offices.

In conjunction with the development of CEFMS, we recommend that a work breakdown structure, similar to the structure presented in Appendix A, be used to collect costs of P&D services for both the advance planning phase and engineering and design phase of USACE projects. We also recommend caution that the structure be kept as simple as possible and that data be collected only at a level deemed essential for sound management information.

We recommend that USACE review its design service policy in the following areas:

- *Value engineering*. Although recognized as a valuable tool, VE may be used excessively. We recommend that USACE review the criteria governing VE. Specifically, we believe a more judicious use of VE will result if it is incorporated as part of the quality control plan for each design project. In this manner, USACE and the customer could decide during project development whether VE is or is not required.

- *Comprehensive interior design*. An increasingly important factor in improving the quality of facilities, CID has not been managed as well as customers would like. We recommend USACE review the policies and practices governing the procurement of CID services and seek ways to improve their delivery.

- *Postconstruction support*. Customers would like to see greater emphasis on the transition of facilities from construction to operational use.

Improvements are needed in the provision of O&M manuals and occupant familiarization and training, particularly for mechanical systems.

LOST DESIGN

We recommend that USACE publish an engineer regulation similar to that presented in Appendix G. It would have four purposes:

- Clarify the definitions of lost design and design breakage
- Provide a uniform format for collecting and reporting lost design data
- Revise the reason codes and their definitions for reporting the causes of lost design
- Improve the accuracy of lost design data.

A high proportion of the reasons for lost design stem from changes made by the user, which usually are the result of poor planning at the installation and MACOM levels. We recommend that USACE adopt a planning review process that would ensure projects are ready for design. We also recommend that USACE authorize early release of P&D funds and, as required, use A-E firms to assist with the review. Since the review is considered part of the design process that must be performed at an early stage of design, we do not consider that this accelerated phasing of the planning and design effort conflicts with the intent of the use of funds specified under the MILCON appropriation.

Consistent with improved project planning is the need to reinforce the value of the PDB. The USACE needs to take immediate steps to improve the quality of each project PDB. Some recent PDBs have provided poor data, reflecting careless preparation; they need to be critiqued and used as examples for making improvements.

LARGE AND COMPLEX PROJECTS

We recommend that USACE identify candidate large and complex projects that may require extraordinary organizational support. The local USACE district should be the preferred source of that support. In some cases, however, the project requirements may exceed a district's design/construction management capability. When this happens, we recommend that USACE exert its influence over divisions and districts to establish temporary organizations to accomplish those extraordinary

projects. Such projects should not be permitted to diminish a district's continuing support to its traditional customers.

We recommend that a fully integrated team be established and include, as a minimum, the USACE project manager, design and construction managers, owner representatives, A-E personnel, and contractors. The team should be in place during the earliest project stages. Similarly, it must be disestablished at project completion. We further recommend the following actions:

- The teams should be given a means for greater flexibility in trading construction funds for design funds to make smarter business decisions. We recommend the USACE create a special funding category for those few special projects to allow greater flexibility in the use of project funds. Congress must be a partner in this initiative.
- The team should place strong emphasis on developing acquisition strategies. USACE should encourage greater use of more flexible contracting methods, including design/build and cost contracting with performance incentives.
- The team should selectively utilize CM consultants to provide specialized experience and management techniques as needed.
- The owner representatives on the team should emphasize the project life-cycle perspective. It is vital to ensure that the owner's functional requirements, operability, and maintainability are considered at each of the project's decision milestones. Additionally, the owner representatives should be responsible for the project continuity from construction through initial occupancy.

PLANNING AND DESIGN RESOURCES MANAGEMENT

We have updated the P&D portion of the CERAMMS model and recommend that USACE Headquarters staff use it in projecting P&D requirements for alternative MILCON program levels. Chapter 5 and Appendix J provide the necessary details on this updated version of CERAMMS.

We recommend using a computer model that will assist design agents in developing workload alternatives to match projected staffing levels. The model described in Chapter 5 and available on computer diskettes will provide that capability. We recommend that model be distributed to all design agents.

GLOSSARY

A-E	=	architect-engineer
AD	=	ammunition depot
ADAL	=	additions and alterations
AFB	=	Air Force Base
AFR	=	Air Force Reserve
AHP	=	analytical hierarchical process
AIA	=	American Institute of Architects
AMPRS	=	Automated Management and Progress Reporting System
ANGB	=	Air National Guard Base
AR	=	Army Regulation
BCM	=	business clearance memorandum
BIOT	=	British Indian Ocean Territory
CAD	=	computer-aided design
CADD	=	computer-aided design and drafting
Catcode	=	category code
CC	=	construction cost
CEFMS	=	Corps of Engineers Financial Management System
CERAMMS	=	Corps of Engineers Resource and Military Manpower System
CID	=	comprehensive interior design
CM	=	construction manager
COEMIS	=	Corps of Engineers Management Information System
CONMOD	=	construction module
CONUS	=	Continental United States

CPM	=	critical path method
CRD	=	certified ready for design
DEH	=	Director of Engineering and Housing
DERP	=	Defense Environmental Restoration Program
DESMOD	=	design module
DOE	=	Department of Energy
ECC	=	estimated construction cost
EDC	=	engineering during construction
EFD	=	engineering field division
ENRC	=	engineering not related to construction
EPA	=	Environmental Protection Agency
ER	=	Engineer Regulation
FAR	=	Federal Acquisition Regulation
FDOT	=	Florida Department of Transportation
FH	=	family housing
FHA	=	Family Housing, Army
FHAF	=	Family Housing, Air Force
FOA	=	field operating activity
GEOTECH	=	geotechnical
GSA	=	General Services Administration
HNTB	=	Howard, Needles, Tammen, Bergendoff
HQDA	=	Headquarters, Department of the Army
HQUSACE	=	Headquarters, U.S. Army Corps of Engineers
HQUSAF	=	Headquarters, U.S. Air Force
HTW	=	hazardous and toxic waste
HVAC	=	heating, ventilating, and air conditioning
IDT	=	indefinite delivery type (contract)

LAN	=	local area network
LMI	=	Logistics Management Institute
LRS	=	logistics resource summary
MACOM	=	major command (Army)
MAJCOM	=	major command (Air Force)
MC	=	military construction
MCA	=	Military Construction, Army
MCAF	=	Military Construction, Air Force
MCAR	=	Military Construction, Army Reserve
MCNM	=	Military Construction, Navy and Marine Corps
MILCON	=	Military Construction
NAF	=	nonappropriated fund
NASA	=	National Aeronautics and Space Administration
NAVFAC	=	Naval Facilities Engineering Command
NORAD	=	North American Air Defense (Command)
OCE	=	Office of the Chief of Engineers
OCONUS	=	outside the Continental United States
OMA	=	Operations and Maintenance, Army
OMAF	=	Operations and Maintenance, Air Force
OMAR	=	Operations and Maintenance, Army Reserve
OSD	=	Office of the Secretary of Defense
PA	=	program amount
PBS	=	production base support
PDB	=	project development brochure
PM	=	project manager
PMO	=	project management office
PMP	=	project management plan

PPBES	=	planning, programming, budgeting, and execution system
PPMDB	=	program and project management data base
PRB	=	project review board
Pre-BCM	=	pre-business clearance memorandum
PY	=	program year
QBS	=	qualifications based selection
RAMP	=	requirements and management plan
RCC	=	Rail Construction Corporation
RDT&E	=	Research, Development, Test, and Evaluation
RFP	=	request for proposal
RFQ	=	request for quotation
SWCC	=	standard work center code
SYDP	=	Six Year Defense Program
USACE	=	U.S. Army Corps of Engineers
VE	=	value engineering
Wkld	=	workload

APPENDIX A

WORK BREAKDOWN STRUCTURE

WORK BREAKDOWN STRUCTURE

The U.S. Army Corps of Engineers (USACE) is reviewing its accounting system and has proposed the use of a work breakdown structure to capture costs. The project will be the primary aggregation of work elements, below which levels of detail can be increasingly defined. In Figure A-1, five major functional areas are shown as a second-level breakdown below the project (represented as Level I).

We were tasked with developing a proposed work breakdown structure for the advance planning and the engineering and design functions. Figures A-2 through A-4 illustrate our proposal for the advance planning function. The Level III function for project management shown in Figure A-4 is equally applicable for both the advance planning and engineering and design functions. Its work elements could also be expanded to include the real estate, construction, and operations functions under the concept of life-cycle project management.

Our proposal for the work breakdown structure for engineering and design is shown in Figures A-5 through A-8.

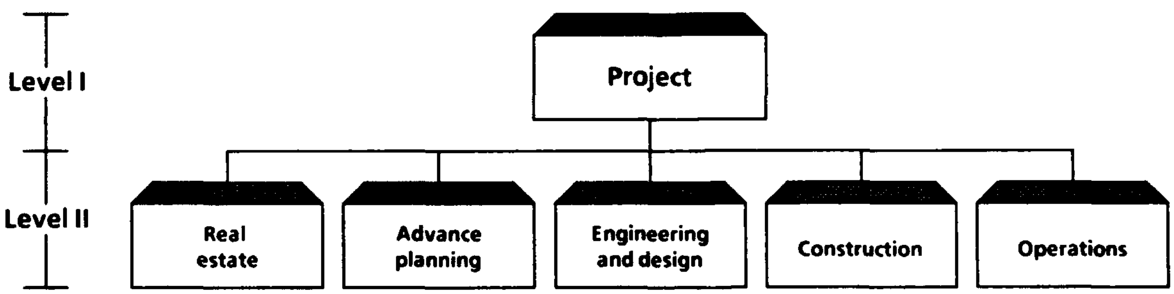
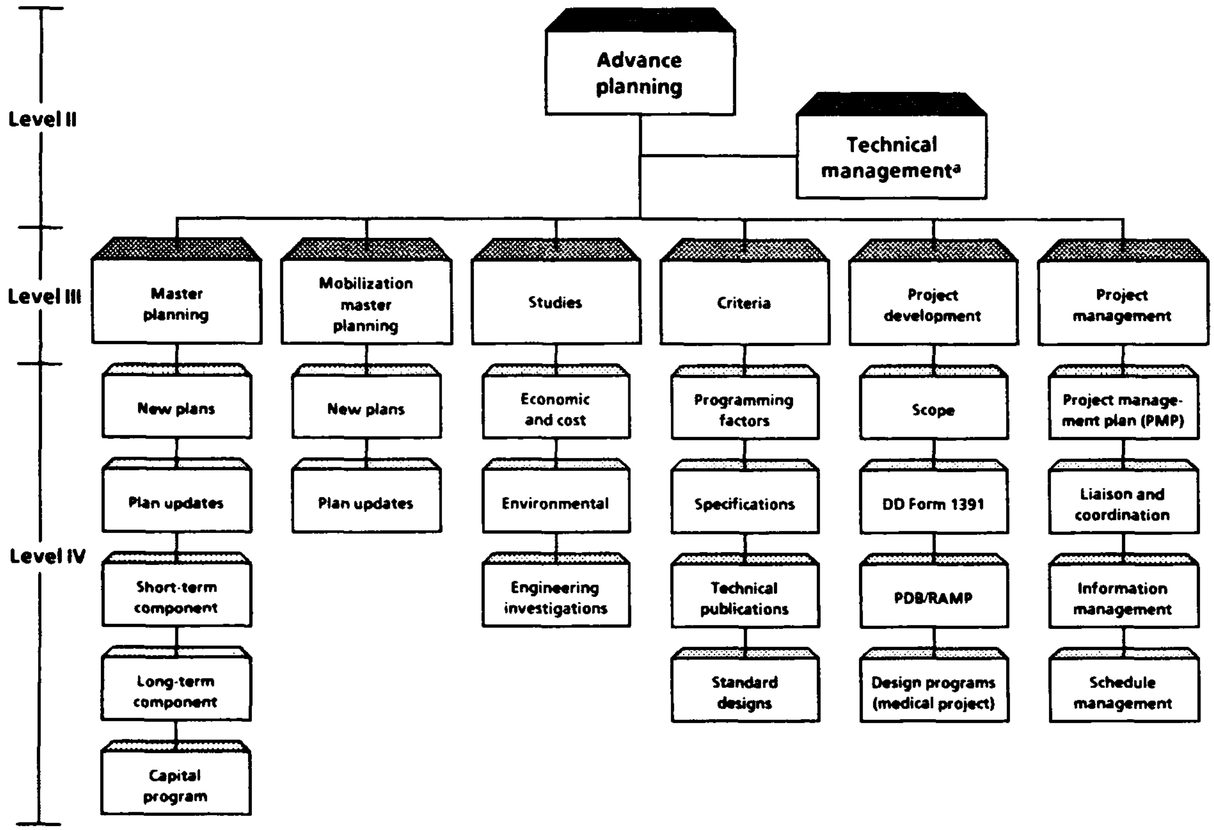


FIG. A-1. WORK BREAKDOWN STRUCTURE



Note: PDB = *Project Development Brochure*; RAMP = Requirements and Management Plan.

[a] As required

FIG. A-2. WORK BREAKDOWN STRUCTURE ADVANCE PLANNING

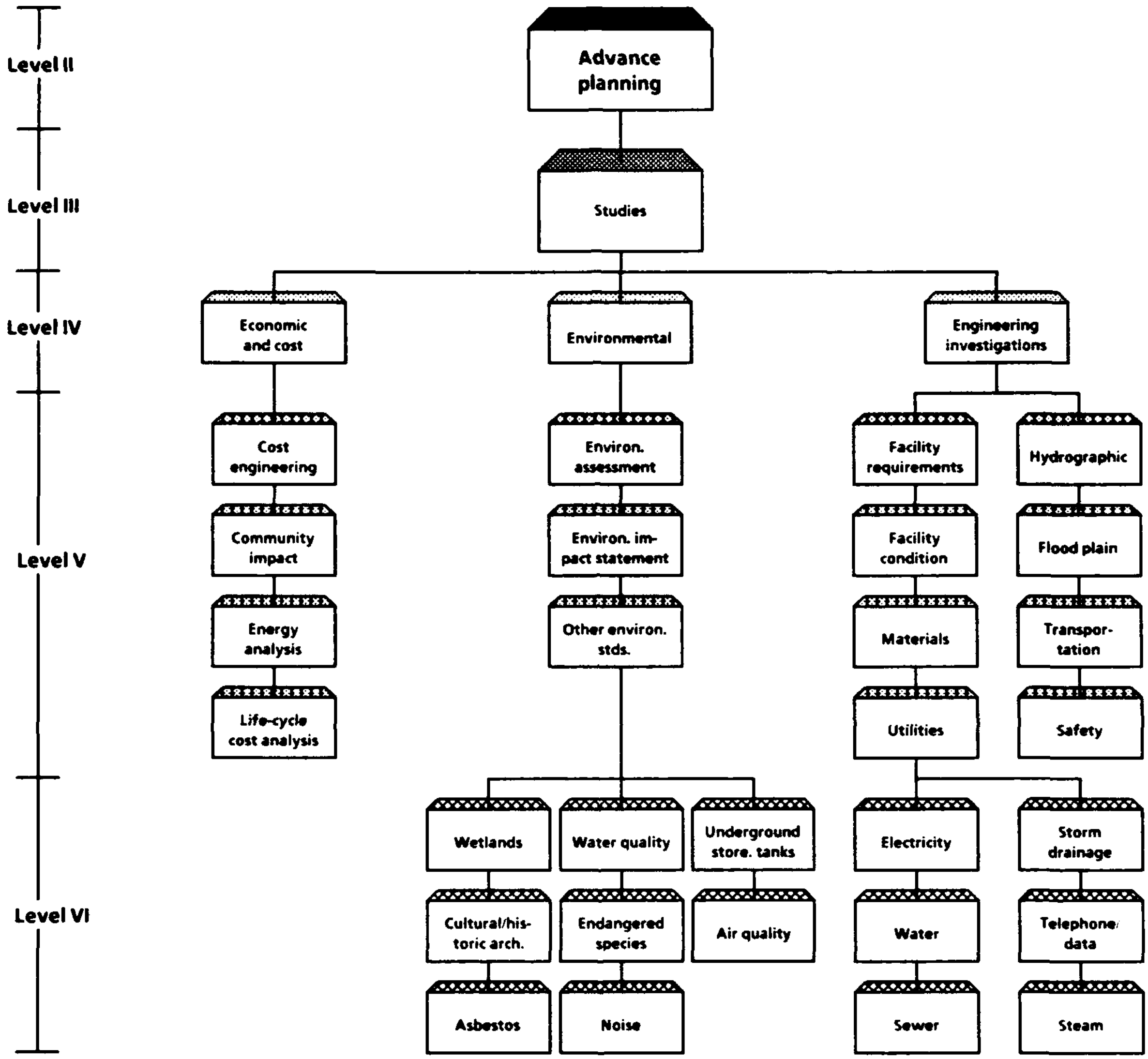
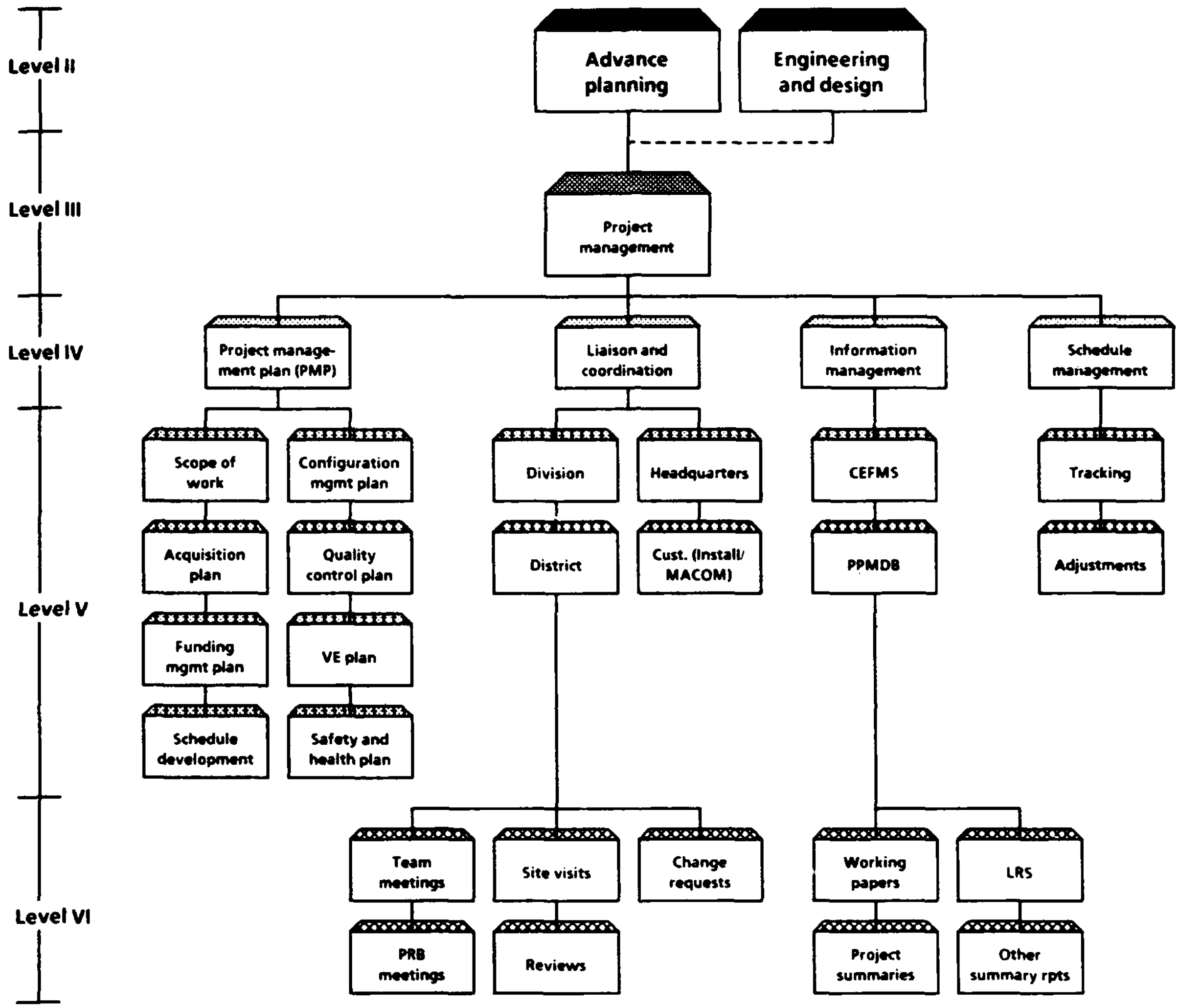
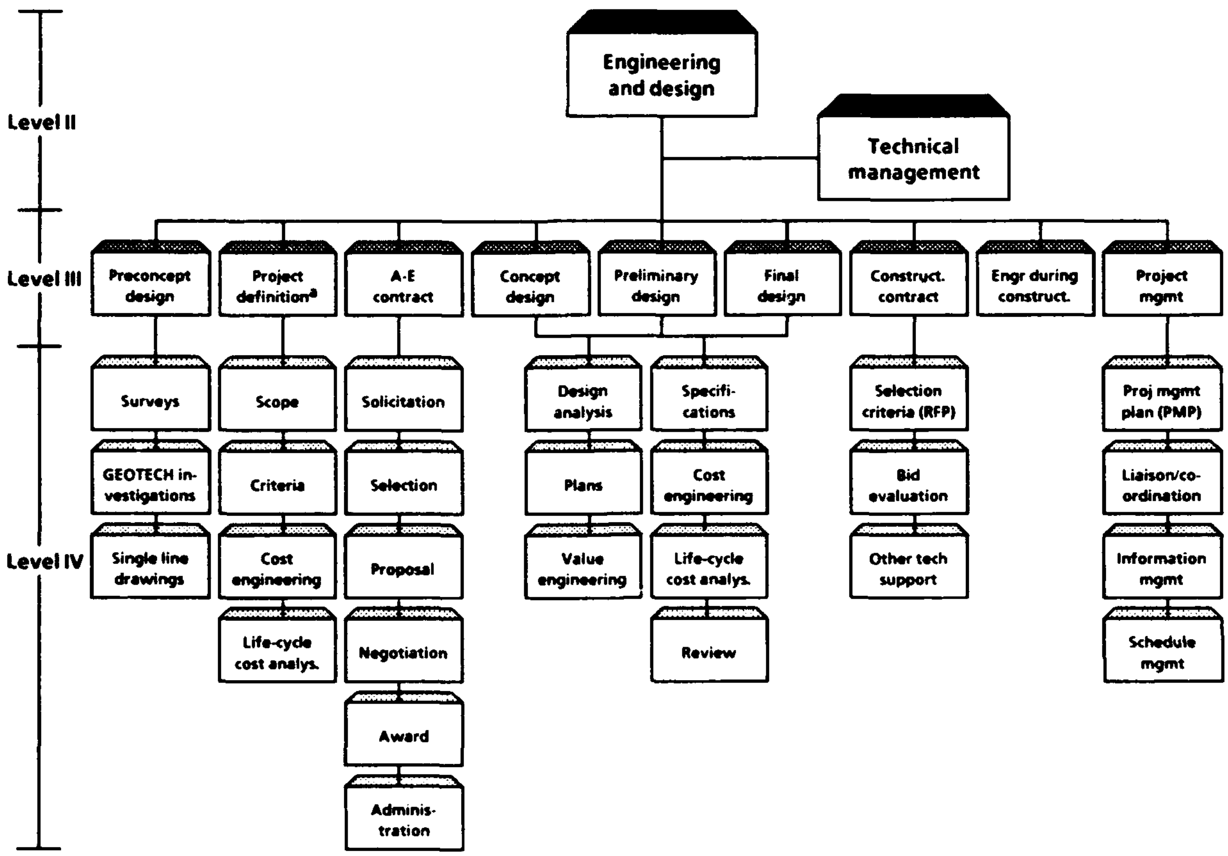


FIG. A-3. WORK BREAKDOWN STRUCTURE ADVANCE PLANNING – STUDIES



Note: VE = value engineering; MACOM = major command (Army); PRB = project review board, CEFMS = Corps of Engineers Financial Management System. PPMDB = Program and Project Management Data Base; LRS = Logistics Resource Summary.

FIG. A-4. WORK BREAKDOWN STRUCTURE ADVANCE PLANNING – PROJECT MANAGEMENT



Note: A-E = architect engineering; RFP = request for proposals

[a] As required.

FIG. A-5. WORK BREAKDOWN STRUCTURE ENGINEERING AND DESIGN

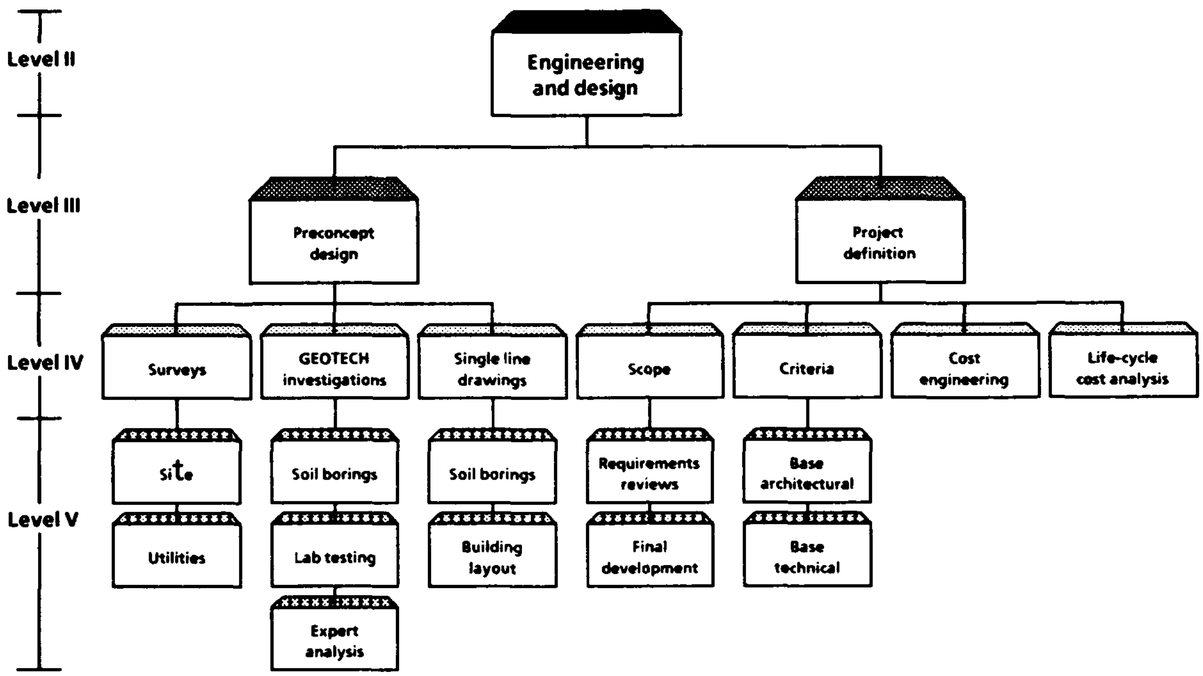
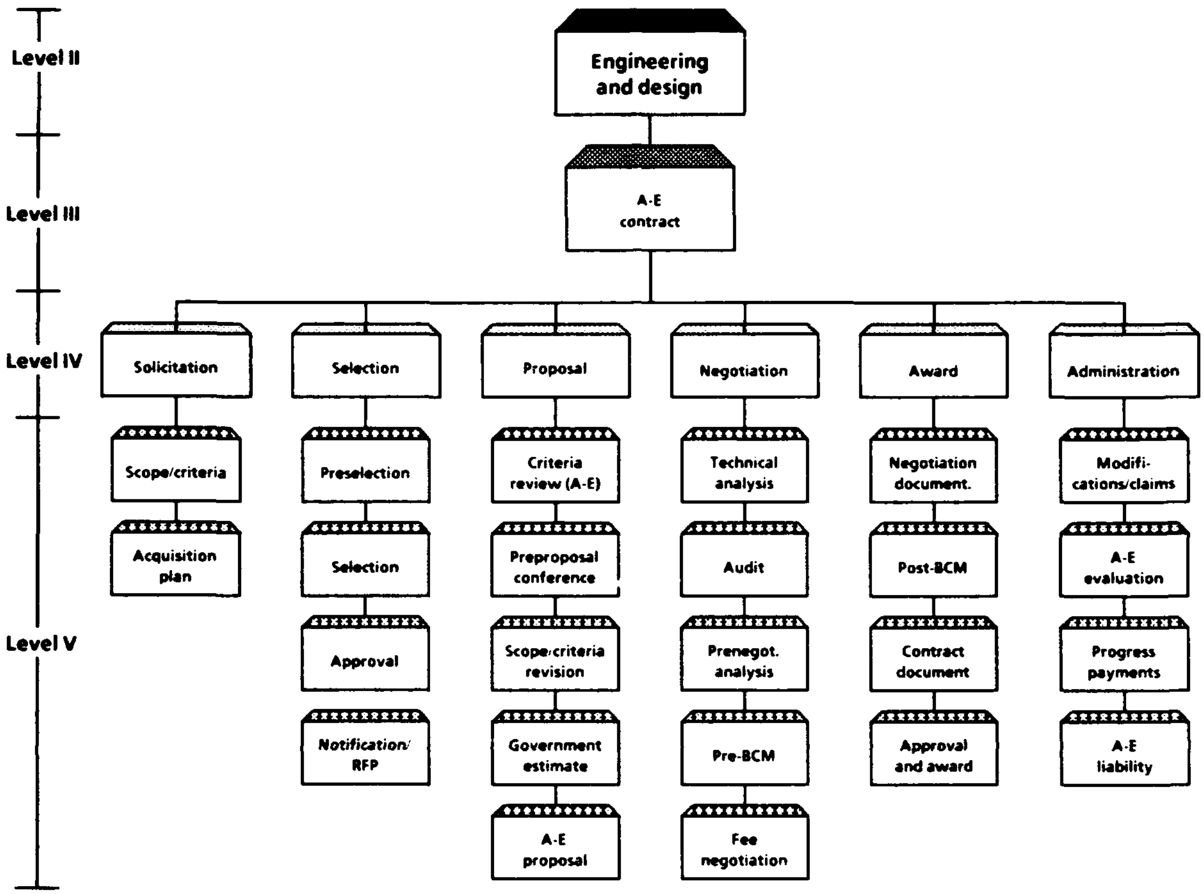
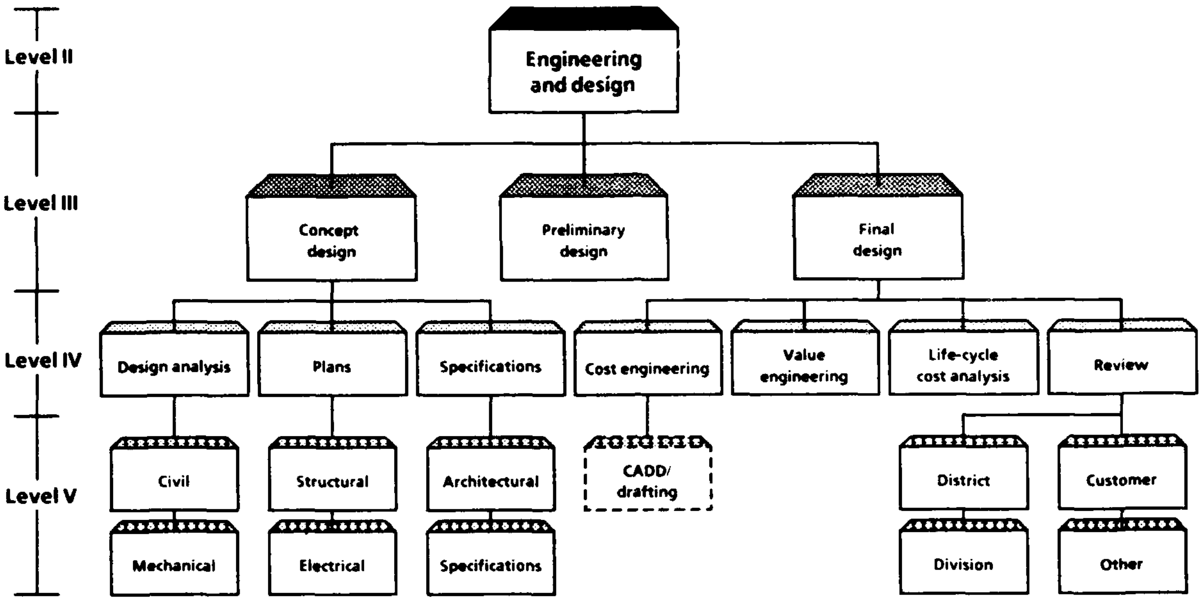


FIG. A-6. WORK BREAKDOWN STRUCTURE ENGINEERING AND DESIGN – PRECONCEPT DESIGN AND PROJECT DEFINITION



Note: A-E = architect-engineer, BCM = business clearance memorandum, RFP = request for proposals

FIG. A-7. WORK BREAKDOWN STRUCTURE ENGINEERING AND DESIGN – A-E CONTRACT



Note: CADD = computer-aided design and drafting

FIG. A-8. WORK BREAKDOWN STRUCTURE ENGINEERING AND DESIGN – CONCEPT, PRELIMINARY, AND FINAL DESIGN

APPENDIX B

U.S. ARMY CORPS OF ENGINEERS (USACE) PLANNING AND DESIGN SERVICES QUESTIONNAIRE

U.S. ARMY CORPS OF ENGINEERS (USACE) PLANNING AND DESIGN SERVICES QUESTIONNAIRE

BACKGROUND AND INSTRUCTIONS: USACE is attempting to improve the planning and design (P&D) services provided to its customers. This questionnaire asks you to rate the frequency, value, and quality of each such service. In some service categories there may be important differences between large and small projects. Therefore, each service should be rated separately for: projects less than $1 million, projects between $1 million to $5 million, and projects greater than $5 million.

This questionnaire has seven sections. Section I requests general information about your installation or command, including some project workload data. Section II addresses the quality of basic design services; Sections III through V address specific P&D service categories. In Section VI, we ask that you evaluate any additional services and/or elaborate upon any services listed within the categories in Sections III, IV, and V. An example is provided in Section II to show how the responses are to be recorded for Sections II through VI. Please answer the open-ended questions and provide any additional comments concerning P&D services in Section VII. Please mail the completed survey in the enclosed envelope to the Logistics Management Institute, who will analyze the results. Your response should be received by 8 February 1991.

SECTION I.

A. Please provide the following information:

______________________________	______________________________
Name of Customer (Command or Installation)	City, State, Country

____________________	______________________________
Primary Corps Office for Design Support	Other Corps Offices that Provide Design Support

____________________	____________________	______________
Name of Person Preparing Form	Position	Phone

B. How many projects does the Corps design for you each year? _______

B1. What percentage of this total number of projects are in the following construction project size categories? < $1 M _____; $1M – $5M _____; > $5M ___; (Total = 100%)

B2. What percentage of this total number of projects are in the following funding categories? MCA ___%; MCAF ___%; MC (Reserve)[1] ___%; O&M[1] ___%; Family Housing[1] ___%; Other ___% (describe[2] ______________); (Total = 100%)

---

[1]Include all customer categories for each group, e.g., MC (Reserve) to include all Army Reserve, National Guard, and Air Force Reserve military construction projects; O&M to include repair and minor construction projects; and Family Housing to include new construction, improvement, and repair projects.

[2]Describe "other" if greater than 25 percent.

SERVICE EVALUATION QUESTIONS FOR SECTION II.

Record the numerical rating response to each question, by construction project size category, for each specified basic design service in the spaces provided below.

Q1. How would you rate the *technical quality* of this design service?
Answers: 1. High quality
2. Medium quality
3. Low quality

Q2. How would rate the *timeliness* in delivering this design service?
Answers: 1. Usually on time
2. Seldom on time, but delays cause only minor impacts
3. Usually late, program impacts occur often

Q3. How would you rate the *cost* of this design service as compared with the preliminary estimate?
Answers: 1. Usually below the estimate
2. Usually at the estimate
3. Usually exceeds the estimate

Example:

Suppose that for a category termed "design," the following ratings apply:

- For construction projects less than $1 million ($1M), the *technical quality* (Q1) is "medium" (rating value 2), the *timeliness* (Q2) is "usually on time" (rating value 1), and the *cost* (Q3) "usually exceeds the estimate" (rating value 3).
- For construction projects from $1 million through $5 million ($1M – $5M) the ratings for Q1 is "high," for Q2 is "seldom on time," and for Q3 is "usually below the estimate."
- For construction projects exceeding $5 million (>$5M) the rating for Q1 is "high," for Q2 is "usually late," and for Q3 is "usually at the estimate."

These responses should appear as follows:

Design.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Technical quality	2	1	1
Q2.	Timeliness	1	3	3
Q3.	Cost	3	1	2

SECTION II. BASIC DESIGN SERVICES

A. *Early Preliminary Design.* Design services through the 10 percent stage.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Technical quality			
Q2.	Timeliness			
Q3.	Cost			

SECTION II. BASIC DESIGN SERVICES (Continued)

B. *Concept Design.* Design services through the 35 percent stage.

Project size:	<\$1M	\$1M – \$5M	>\$5M
Q1. Technical quality	______	______	______
Q2. Timeliness	______	______	______
Q3. Cost	______	______	______

C. *Final Design.* Design services through the 95 percent stage.

Project size:	<\$1M	\$1M – \$5M	>\$5M
Q1. Technical quality	______	______	______
Q2. Timeliness	______	______	______
Q3. Cost	______	______	______

SERVICE EVALUATION QUESTIONS FOR SECTIONS III, IV, V, AND VI

Record the numerical rating response to each question in the corresponding space provided under each construction project size category for each of the services listed in Sections III, IV, and V.

Q1. How *frequently* do you use this service?
Answers:
1. Always use
2. Frequently use
3. Occasionally use
4. Never use

Q2. What is the *value* of this service (include mission effectiveness, job effectiveness, and higher authority requirements)?
Answers:
1. High value
2. Medium value
3. Low value

Q3. How would you rate the *quality* of this service (include timeliness and technical quality)?
Answers:
1. High quality
2. Medium quality
3. Low quality

SECTION III. PREDESIGN SERVICES

A. *Planning.* Includes master planning, project development brochures, DD Form 1391, etc.

Project size:	<\$1M	\$1M – \$5M	>\$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

SECTION III. **PREDESIGN SERVICES** (Continued)

B. *Environmental Studies*. Includes assessments, impact statements, permits, etc.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

C. *Economic Studies*.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

D. *Cultural/Historic Studies*.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

E. *Feasibility Studies*. Includes engineering, asbestos, condition, energy, utilities, traffic, material, site investigations, soil borings, etc.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

F. *Mapping and Surveys*.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

G. *Other Studies*. Includes emergency mobilization, hazardous and toxic waste, etc.

	Project size:	<$1M	$1M – $5M	>$5M
Q1.	Frequency of service use	______	______	______
Q2.	Value of service	______	______	______
Q3.	Quality of service	______	______	______

SECTION IV. PLANNING AND DESIGN MANAGEMENT SERVICES

A. *A-E Contract Services*. Includes solicitation/selection, proposal/negotiation, award, etc.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

B. *Project Management Services*. Includes scope/criteria, scheduling, financial, changes, reviews, etc.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

C. *Engineering Management Services.*

C.1. *Value Engineering Services.*

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

C.2. *Design Review Services.*

10 Percent Review (Early Preliminary)[3]

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

35 Percent Review (Concept)[3]

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

60 Percent Review (Design Development)[3]

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

---

[3]Review descriptions sometimes vary with customers and other Military Services.

SECTION IV. PLANNING AND DESIGN MANAGEMENT SERVICES (Continued)

95 Percent Review (Final)[3]

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

Back Check Review

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

D. *P&D Support of Construction Management.* Includes constructability reviews, shop drawing reviews, value engineering, equipment/furnishing installation, and post-occupancy evaluations.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

SECTION V. SPECIAL SERVICES

A. *Interior Design.* Includes comprehensive, building- and furniture-related interior design.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

B. *Renderings, Models, and Other Promotional.*

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

C. *Printing/Reproduction.*

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

D. *Special Mail/Distribution*

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use			
Q2. Value of service			
Q3. Quality of service			

SECTION V. SPECIAL SERVICES (Continued)

E. *Legal Services.* Includes claims, hearings, legislative reviews, etc.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

F. *O&M Manuals.* Includes manuals for equipment operation, maintenance requirements, furnishing specifications, etc.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

G. *Client Training.* Includes factory or special training on complex systems such as energy monitoring controls and intrusion detection.

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

SECTION VI. ADDITIONAL SERVICES (Please describe or explain)

A. ____

____

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

B. ____

____

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

C. ____

____

Project size:	<$1M	$1M – $5M	>$5M
Q1. Frequency of service use	______	______	______
Q2. Value of service	______	______	______
Q3. Quality of service	______	______	______

SECTION VII. ADDITIONAL QUESTIONS/COMMENTS

A. What USACE services would you recommend be eliminated, if any? ______________

Explain ____

____

____

B. What additional services should USACE provide? ______________

Explain ____

____

____

C. Any other comments?

____

____

____

____

Thank you for taking time to answer these questions. Please return the survey to:

Logistics Management Institute
Attention: J. L. Hathaway
6400 Goldsboro Road
Bethesda, MD 20817-5886

APPENDIX C

ANALYSIS OF SURVEY RESPONSES

ANALYSIS OF SURVEY RESPONSES

A survey of Army and Air Force customer installations and U.S. Army Corps of Engineers (USACE) districts and divisions was conducted to evaluate the frequency, value, and quality of planning and design services provided by USACE. (See Appendix B.) An analysis of the responses revealed that some of the services fall outside a normal distribution of all responses received. Tables C-1 and C-2 depict those survey responses on services above and below satisfactory levels compared with all other services.

TABLE C-1

SURVEY RESPONSES WITH HIGHER SATISFACTION LEVELS

Service	Frequency			Value			Quality		
	A	B	C	A	B	C	A	B	C
Environmental Studies									●
Cultural/Historic Studies								●	●
Feasibility Studies					●				●
Mapping and Surveys							●	●	●
Other Studies							●	●	●
A-E Contract Services	●	●	●	●	●	●		●	●
Project Management Services	●	●	●						●
10 Percent Design Review		●	●			●			
35 Percent Design Review	●	●	●						
60 Percent Design Review			●						
95 Percent Design Review	●	●	●	●	●	●			
Back Check Review		●	●						
P&D Support of Construction Management		●	●						
Printing/Reproduction				●	●	●	●	●	●
Mail/Postage						●	●	●	●
Operation and Maintenance Manuals			●			●			
Client Training				●		●			

Note: A = less than \$1 million; B = \$1 million to \$5 million; C = greater than \$5 million; A-E = architect-engineer

TABLE C-2

SURVEY RESPONSES WITH LOWER SATISFACTION LEVELS

Service	Frequency			Value			Quality		
	A	B	C	A	B	C	A	B	C
Planning	●		●	●					
Economic Studies	●	●	●	●	●	●			
Cultural/Historic Studies	●	●	●			●			
Mapping and Surveys			●						
Other Studies		●	●						
Value Engineering Services	●			●	●	●	●	●	●
10 Percent Design Review				●			●		
Back Check Review				●			●		
P&D Support of Construction Management							●	●	
Interior Design	●	●		●	●		●	●	●
Renderings, Models, and Other Promotional	●	●	●	●	●				
Legal Services	●	●							
O&M Manuals							●	●	●
Client Training	●						●	●	●

Note: A = less than $1 million; B = $1 million to $5 million; C = greater than $5 million

APPENDIX D

REASON CODES FOR LOST DESIGN DEFINITIONS

REASON CODES FOR LOST DESIGN DEFINITIONS

Lost design can occur for many reasons. The following list of reasons, intended to be coded for reporting to higher authority, gives a definition for each reason to provide uniformity in the reporting process. The reasons are grouped into four broad categories, each representing either a level in the chain of command or a particular phase of the design process.

A. *Higher Authority Change.* Changes directed by a level above the organization charged with executing the mission supported by the project. Congressional, OSD, or Service Headquarters staffs would be the usual sources of these changes.

A.1. *Program Amount.* Changes in available funding imposed by higher authority, e.g., program/budget revisions, appropriated amounts, and Service reallocations after appropriation.

A.2. *Scope.* Changes in scope to a project directed by higher authority, e.g., expanded requirement.

A.3. *Criteria.* Changes in criteria directed by higher authority.

A.4. *Weapon System.* Changes in design caused by revisions to a weapon system, e.g., reduced production rate, different basing scheme, etc.

A.5. *Schedule.* Changes caused by program delays or accelerations directed by higher authority.

B. *User Changes.* Changes usually imposed by the installation, operating unit, or major command.

B.1. *Available Funding.* Changes resulting from redesign to keep project within funding availability.

B.2. *Scope.* Changes caused by technical difficulties, planning omissions, etc.

B.3. *Criteria.* Changes caused by command preference, technology advances, and facts of life.

B.4. *Weapon System.* Inadequate facilities planning during weapon system development; bed-down reality.

B.5. *Schedule.* Changes resulting from a scheduling constraint imposed by the using activity.

C. *Cost Constraints.* Changes resulting from funding shortfalls.

C.1. *Redesign Within Available Funds.* Redesign required as a result of a funding shortfall.

C.2. *Additions Not Awarded.* Projects with construction contract additive bid items requiring design that are not awarded because of funding constraints.

C.3. *Schedule Delays.* Redesign caused by delays that occur because of cost constraints encountered during the design process.

D. *Design Error or Omission.* Changes resulting from inadequate performance on the part of the design agent or the A-E.

D.1. *A-E Design Error.* Changes resulting from inadequate design provided by the A-E.

D.2. *In-House Design Error.* Changes due to inadequate design provided by the in-house design team.

D.3. *Design Agent Error.* Changes due to inadequate guidance to the A-E including vague contract language, ambiguous criteria, etc.

APPENDIX E

DOCUMENTATION OF LOST DESIGN FORM

DOCUMENTATION OF LOST DESIGN

1 PROJECT	ROUTING 1 2 3
2. LOCATION	3 PROG YR

4. PROJECT NO.	5. AMPRS PROJ. KEY	6 COEMIS WORKCODE

DEFINITIONS:

Breakage: **Design that has incurred a cost for any project not planned to be constructed as part of an ongoing or planned program is design breakage. Design breakage includes project cancellations and projects deferred beyond the Six Year Defense Program (SYDP). Breakage is not reported as lost design. Projects that were previously reported as incurring lost design and that subsequently fall into the category of design breakage will have all design costs reported as design breakage.**

Lost Design: ***Design that has incurred a cost which must be scrapped and/or redone prior to award of a construction contract because of changes in the scope of a project, criteria, weapon system requirements, design error, or any other reason that invalidates portions of a design is lost design.***

NOTE:

(1) ***Scope designed as an additive construction contract bid item, but not awarded, is included as lost design.***

(2) ***Design changes that do not result in increased design cost are not lost design.***

(3) ***The cost of Value Engineering (VE) studies and any contract modification costs related to a VE study are not included as lost design.***

7. ESTIMATE OF LOST DESIGN COST

ORGANIZATION	OFFICE SYMBOL	TOTAL MAN-HOURS	DESIGN COST	ADP WORKCODE
ENGINEERING DIVISION STAFF				
SOILS SECTION				
GEOLOGY SECTION				
SITE DEVELOPMENT SECTION				
SURVEY SECTION				
ELECTRICAL SECTION				
MOD & SPECIFICATIONS SEC				
COST ENGINEERING SECTION				
MECHANICAL SECTION				
DRAFTING SECTION				
STRUCTURAL SECTION				
ARCHITECTURAL SECTION				
DESIGN BRANCH				
MILITARY PLANNING SECTION				
ARMY PROJECT MGMT SECTION				
AIR FORCE PROJECT MGMT SEC				
FAC ENGR SUPPORT SECTION				
PROGRAM MANAGEMENT SEC				
SURVEY FIELD				
CORE DRILL OPER				
REPRODUCTION BRANCH				
A-E SURVEY				
A-E DESIGN				
TOTAL				

8. LOST DESIGN PERIOD *(report to nearest month end)*:
From ____________ To ____________

9. PERCENT COMPLETE WHEN LOST DESIGN OCCURRED
__________%.

10. CITE DIRECTIVE, CORRESPONDENCE, OR OTHER BASIS FOR LOST DESIGN:

(Reserved for use by Program Mgmt Section ONLY)

11 REASON CODES FOR LOST DESIGN (See definitions on reverse.)

A HIGHER AUTHORITY CHANGE	B USER CHANGES	C COST CONSTRAINTS	D DESIGN ERROR OR OMISSION
☐ Program Amount	☐ Available Funding	☐ Redesign Within Available Funds	☐ A-E Design Error
☐ Scope	☐ Scope	☐ Additions Not Awarded	☐ In-House Design Error
☐ Criteria	☐ Criteria	☐ Schedule Delays	☐ Design Agent Error
☐ Weapon System	☐ Weapon System		
☐ Schedule	☐ Schedule		

12 PREPARED BY	OFFICE SYMBOL	DATE

LOST DESIGN REASON CODE DEFINITIONS

Lost design can occur for many reasons. The following list of reasons, intended to be coded for reporting to higher authority, gives a definition for each reason to provide uniformity in the reporting process. The reasons are grouped into five broad categories, each representing either a level in the chain of command or a particular phase of the design/construction process.

A. *Higher Authority Change.* Changes directed by a level above the organization charged with executing the mission supported by the project. Congressional, OSD, or Service Headquarters staffs would be the usual sources of these changes.

A.1. *Program Amount.* Changes in available funding imposed by higher authority, e.g., program/budget revisions, appropriated amounts, and Service reallocations after appropriation.

A.2. *Scope.* Changes in scope to a project directed by higher authority, e.g., expanded requirement.

A.3. *Criteria.* Changes in criteria directed by higher authority.

A.4. *Weapon System.* Changes in design caused by revisions to a weapon system, e.g., reduced production rate, different basing scheme, etc.

A.5. *Schedule.* Changes caused by program delays or accelerations directed by higher authority.

B. *User Changes.* Changes usually imposed by the installation, operating unit, or major command.

B.1. *Available Funding.* Changes resulting from redesign to keep project within funding availability.

B.2. *Scope.* Changes caused by technical difficulties, planning omissions, etc.

B.3. *Criteria.* Changes caused by command preference, technology advances, and facts of life.

B.4. *Weapon System.* Inadequate facilities planning during weapon system development; bed-down reality.

B.5. *Schedule.* Changes resulting from a scheduling constraint imposed by the using activity.

C. *Cost Constraints.* Changes resulting from funding shortfalls.

C.1. *Redesign Within Available Funds.* Redesign required as a result of a funding shortfall.

C.2. *Additions Not Awarded.* Projects with construction contract additive bid items requiring design that are not awarded because of funding constraints.

C.3. *Schedule Delays.* Redesign caused by delays that occur because of cost constraints encountered during the design process.

D. *Design Error or Omission.* Changes resulting from inadequate performance on the part of the design agent or the A-E.

D.1. *A-E Design Error.* Changes resulting from inadequate design provided by the A-E.

D.2. *In-House Design Error.* Changes due to inadequate design provided by the in-house design team.

D.3. *Design Agent Error.* Changes due to inadequate guidance to the A-E including vague contract language, ambiguous criteria, etc.

APPENDIX F

LOST DESIGN FREQUENCY/COST INDICES

LOST DESIGN FREQUENCY/COST INDICES

Using an Expert Choice technique, a group of U.S. Army Corps of Engineers (USACE) experts was asked to rank order the 16 reasons for lost design. The first-order ranking was for frequency of occurrence and the second for cost impact. A separate order ranking for frequency was also developed for Army and Air Force Military Construction Appropriations (MCA and (MCAF).

By multiplying the weighted frequency and cost indices, a savings index for both MCA and MCAF is obtained. Table F-1 displays the Expert Choice results. The three top user change categories of criteria, weapon systems, and scope contribute a significantly heavier lost design cost impact for both appropriation categories than do any of the other reasons for lost design.

TABLE F-1

POTENTIAL LOST DESIGN SAVINGS

Reason code	Description	MCA frequency	MCAF frequency	Cost factors	MCA savings index	MCAF Air Force savings index
B.3.	User changes – criteria	0.282	0.298	0.141	0.0398	0.0420
B.4.	User changes – weapon system	0.059	0.062	0.227	0.0134	0.0141
B.2.	User changes – scope	0.151	0.160	0.077	0.0116	0.0123
D.1.	A-E Design error	0.082	0.090	0.035	0.0029	0.0032
E.1.[a]	Differing site conditions	0.027	0.027	0.095	0.0026	0.0026
C.1.	Redesign within available funds	0.088	0.032	0.029	0.0026	0.0009
E.2.[a]	Changed conditions – regulatory	0.008	0.012	0.152	0.0012	0.0018
D.3.	Design agent error	0.023	0.028	0.050	0.0012	0.0014
B.5.	User changes – schedule	0.025	0.027	0.040	0.0010	0.0011
A.5.	Higher authority change – schedule	0.043	0.019	0.019	0.0008	0.0004
A.3.	Higher authority change – criteria	0.076	0.031	0.009	0.0007	0.0003
D.2.	In-house design error	0.012	0.013	0.048	0.0006	0.0006
B.1.	User changes – available funding (constraint)	0.029	0.030	0.017	0.0005	0.0005
A.4.	Higher authority change – weapon system	0.013	0.069	0.031	0.0004	0.0021
C.3.	Cost constraints – schedule delays (during design)	0.021	0.014	0.017	0.0004	0.0002
C.2.	Cost constraints – additions not awarded	0.030	0.073	0.006	0.0002	0.0004
A.2.	Higher authority change – scope	0.023	0.005	0.002	0.0000	0.0000
A.1.	Higher authority change – program amount (constraint)	0.007	0.005	0.002	0.0000	0.0000

[a] Reason Codes E.1. and E.2. generally occur after construction has begun and therefore, are not included as lost design. They were found to be important factors in the overall redesign effort.

APPENDIX G

LOST DESIGN ENGINEER REGULATION

DEPARTMENT OF THE ARMY
U. S. Army Corps of Engineers
Washington, D. C. 20314-1000

CEMP-ES

Regulation
No. 1140-1-12

LOST DESIGN

1. **Purpose.** This regulation establishes procedures for identifying, reporting, and controlling lost design.

2. **Applicability.** This regulation applies to HQUSACE/OCE elements, major subordinate commands, districts, laboratories, and field operating activities (FOAs).

3. **Policy.**

a. All Corps offices involved in the design of construction projects shall establish effective internal methods to identify, report, and control lost design.

b. The definition of lost design and codes that describe the reasons for its occurrence, as set forth in this regulation, shall be used to report lost design.

4. **General.**

a. The Congress requires that design that must be redone during execution of the Military Construction (MILCON) program be reported annually. The results of recent DoD investigations reveal that lost design is under-reported.

b. Lost design is a measure of inefficiency and uncertainty in the planning and design process. Changes in criteria or siting after design has begun are typical causes of lost design. Lost design is sometimes beyond the control of the design agent or even the customer (installation or major command). For example, changes made at higher levels, such as force realignment, weapon system reconfiguration, and funding controls can incur lost design. To improve the control of lost design, it is imperative that all lost design be reported and that reasons for its occurrence be identified.

c. Concurrent with improved reporting of lost design, separate initiatives will be pursued to control the occurrence of lost design. Better project planning and programming are needed to improve control. Corporate groups should discourage user-originated changes during design. Clearly, as lost design reporting is improved, lost-design reduction measures can be implemented more effectively.

5. **Definitions.**

a. **Lost Design.** Design that has incurred a cost that must be scrapped and/or redone prior to award of a construction contract because of changes in the scope of a project, criteria, weapon system requirement, design error, or any other reason that invalidates portions of a design is lost design. Design of an unawarded construction contract additive bid item is included as lost design. Design changes that do not result in

increased design cost, and value engineering (VE) studies and any modification costs related to a VE study are not included as lost design.

b. **Design Breakage.** Design that has incurred a cost for any project not planned to be constructed as part of an ongoing or planned construction program is design breakage. Design breakage includes program drops, project cancellations, and projects deferred beyond the Six Year Defense Program (SYDP). Design breakage is not reported as lost design. Projects that were previously reported as incurring lost design and that subsequently fall into the category of design breakage will have all design costs reported as design breakage.

6. **Responsibilities.**

a. The Director of Military Programs, HQUSACE, and commanders of major subordinate commands and districts are responsible for establishing/implementing internal methods, as necessary, to ensure that lost design is accurately reported and controlled.

b. The Director of Military Programs, HQUSACE, and commanders of major subordinate commands shall monitor progress in lost design reporting and initiate action where required to improve the control of lost design.

c. The Corporate Group shall approve all user-originated changes, including siting, that are within the project scope approved by Congress. User-originated changes will be evaluated on merit, considering design and other cost impacts.

7. **Reporting.** Lost design for all projects initiated on or after 1 March 1992 shall be reported in the Automated Management Reporting System - (AMPRS) - using the reason codes listed and defined in Appendix A. The format for lost design reporting in Appendix B is recommended to assist districts in recording lost design consistent with the definitions and reason codes established in this regulation.

FOR THE COMMANDER:

2 APPENDICES
APP A - Lost Design Reason Codes and Definitions
APP B - Format for Recording Lost Design

APPENDIX H

DESIGN SERVICES AND COSTS FOR NINE SAMPLE USACE LARGE AND COMPLEX PROJECTS

DESIGN SERVICES AND COSTS FOR NINE SAMPLE USACE LARGE AND COMPLEX PROJECTS

DESIGN COSTS

We analyzed data provided by U.S. Army Corps of Engineers (USACE) district offices for nine exemplary large and complex projects completed by the Government. Those projects and their program year and program amount (PA) are shown in Table H-1. Table H-2 displays a summary of planning and design (P&D) costs as a percentage of PA by architect-engineer (A-E) firms and in-house effort, and by concept and final phases.

TABLE H-1

NINE SAMPLE USACE LARGE/COMPLEX PROJECTS

Project number	Project description	Program year	PA ($ million)
1	Guided Weapons and Evaluation Facility, Eglin AFB, FL	88	20.0
2	Solid Motor Assembly Building, Cape Canaveral, FL	90	89.0
3	Large Rocket Test Facility, Arnold Engineering and Development Center, TN	89	226.0
4	NORAD and Space Command Headquarters, Peterson AFB, CO	85	19.0
5	Hydrant Fuel System Griffiss AFB, NY	90	7.6
6	ADAL Aerospace Data Facility Buckley ANGB, CO	88	15.5
7	B-2 Test Support Facility Edwards AFB, CA	85/86	85.0
8	Consolidated Maintenance Facility, Tooele AD, UT	89	37.0
9	Standby Power Plant Vandenberg AFB, CA	85	15.9

Note: AFB = Air Force Base; NORAD = North American Air Defense; ADAL = Additions and Alterations; ANGB = Air National Guard Base; AD = Ammunition Depot.

TABLE H-2

PLANNING AND DESIGN RATIOS FOR NINE PROJECTS

Project number	Project description	Overall P&D (percent of PA)	A-E (percent of PA)	In-house (percent of PA)	Concept design (percent of PA)	Final design (percent of PA)
1	Guided Weapons and Evaluation Facility, Eglin AFB, FL	7.89	6.16	1.73	2.57	5.32
2	Solid Motor Assembly Building, Cape Canaveral, FL	7.44	6.22	1.23	2.55	4.89
3	Large Rocket Test Facility Arnold Engineering and Development Center, TN	7.93	5.24	2.69	3.40	4.53
4	NORAD and Space Command Headquarters, Peterson AFB, CO	11.27	10.04	1.23	3.72	7.55
5	Hydrant Fuel System Griffiss AFB, NY	6.67	[a]	6.67	1.57	5.10
6	ADAL Aerospace Data Facility, Buckley ANGB, CO	10.80	9.56	1.24	3.71	7.09
7	B-2 Test Support Facility Edwards AFB, CA	6.32	5.67	0.65	2.18	4.14
8	Consolidated Maintenance Facility, Tooele AD, UT	7.82	6.16	1.66	2.40	5.42
9	Standby Power Plant Vandenberg AFB, CA	9.56	7.85	1.71	2.77	6.79
	Weighted percent of PA	7.96	6.10[b]	1.86[b]	2.98	4.98

[a] Project design in-house.

[b] Less than in-house project.

The weighted average for the overall P&D ratio – P&D cost as a percentage of PA – at 7.96 percent, is about 1 percent higher than the historic average for projects in the same size category funded by the Air Force Military Construction (MILCON) appropriation. A reduction of the P&D ratio of 1 percent for this sample list of projects would have resulted in a saving of $5 million in the cost of P&D. For the eight projects done by A-E firms, 1.86 percent of PA or 23 percent of the P&D cost was required for in-house support. The average share of design costs associated with the

concept phase was 37 percent, which closely follows the 35 percent criteria established by Congress for submittal of concept drawings.

DESIGN SERVICES

In Table H-3, we list the design services that were identified separately for the nine exemplary projects. Those services are additional to the basic services for concept and final designs. Their costs are presented as percentages of the PA. The costs combine both A-E firm and in-house costs if separate costs for each were identified.

Wide variation both in the services identified and the costs for each service was found. We do not suggest that these costs be used as a cost guide; rather, they serve to illustrate the diversity and range of costs that can be expected in large and complex projects.

TABLE H-3

DESIGN SERVICES AND PERCENT OF PROGRAM AMOUNT

Technical services	Project number								
	1	2	3	4	5	6	7	8	9
Site investigations	.07	.05							
Existing conditions survey						.70			
Topographic study		.02					.13		
Geotechnical (test piles/core drilling)		.41	.08						
Seismographic survey	.06								
Life-cycle cost study/optimization	.04	.04	.12					.24	1.19
Value engineering (VE) study	.18	.06	.16				.14		
Energy budget	.04	.04							
Architectural study	.03	.01							
Architectural design requirements	.05								
Structural study	.01								
Vibration analysis study	.11								
Landscaping/irrigation system				0.10					
Mechanical study		.06							
Noise suppression system						.40			
Fatigue and surge analysis					.32				
Electrical study		.03							
Building addition as a bid additive						.62			
Existing water supply study		.01							
Phasing study		.02							
Construction review		.06	.08						
Construction management consultation		.06	.18						
Construction critical path method (CPM)							.03		
3-dimensional model		.16							
Rendering	.01					.04			
Environmental assessment		.01							
Environmental permits	.01	.04							2.35
Asbestos survey						.06			
Comprehensive interior design (CID)	.30			1.62		1.32			
System furniture study/alternate layouts	.02					.09			
Area office design		.01							
Drill water well		.02							
Administrative services									
Conferences/conference minutes	.19	.17					.09	.30	.99
Technical interchange meetings		.08							
Briefing/presentation			.02						
Travel	.28	.09							
Reproduction	.28	.29					.08	.01	.06
Postage	.01	.04							
Long distance calls		.01							
Management information system				.40					
Local area network (LAN)	.05		.13						
Design reviews		.18							

APPENDIX I

FIVE SELECTED NONFEDERAL PROJECTS

FIVE SELECTED NONFEDERAL PROJECTS

With the help of Mr. Gregory B. Coleman, Vice President of the American Consulting Engineers Council, and key industry representatives we were able to gain valuable project planning and design information from these five non-Federal projects. On-site interviews with senior project managers and engineers enabled us to gain insights into those factors that distinguish large and complex projects from more typical construction projects. Following is a list of the personnel contacted:

John F. Kennedy Airport Redevelopment Program, New York, N.Y.

Mr. Richard J. Smyth, Vice President and Program Manager, O'Brien-Kreitzberg & Associates, Jamaica, N.Y.

Mr. Louis Tucciarone, Assistant Program Manager, O'Brien-Kreitzberg & Associates, Jamaica, N.Y.

Milwaukee Water Pollution Abatement Program, Milwaukee, Wis.

Mr. Gary D. Beech, Vice President and Program Director, CH2M Hill, Milwaukee, Wis.

Port Everglades Expressway (I-595), Broward County, Fla.

Mr. R. E. Alexander, Vice President, ICF Kaiser Engineers, Ft. Lauderdale, Fla.

Mr. Harry Bertossa, Associate, Howard Needles Tammen & Bergendoff, Orlando, Fla.

Hyperion Energy Recovery System Plant, Los Angeles, Cal.

Mr. Thom Francis, Vice President, Operations, SE Technologies, Inc.Bridgeville, Pa.

Mr. Jeffrey L. Pierce, Department Manager, Schneider, Inc. (Subsidiary of SE Technologies), Playa Del Rey, Cal.

Los Angeles County, Light Rail System, Cal.

Mr. David J. Sievers, Program Manager, Rail Construction Corporation (Subsidiary of the Los Angeles County Transportation Commission), Los Angeles, Cal.

Mr. Don E. Stiner, Manager of Program Control, Rail Construction Corporation, Los Angeles, Cal.

A brief summary and description of the key planning and design features associated with each project follows.

JOHN F. KENNEDY AIRPORT REDEVELOPMENT PROGRAM

Project Description

Often referred to as "JFK 2000," this $3.2 billion project to be accomplished over a 10-year period will permit an annual increase in passenger capacity from 15 million to 45 million although it currently handles nearly 30 million passengers annually. Major projects to be phased in include rerouted expressway connections and circulation system, new central terminal complex, international arrivals building, control tower, expanded terminals, cargo facilities, hotel and related private development, and support facilities.

Client/Architect-Engineer Relationship

The Port Authority of New York and New Jersey, together with its tunnel and waterfront facilities and operations and its transportation systems, owns and operates JFK Airport. The Port Authority has an extremely capable and extensive in-house engineering and design organization. However, because of its large and complex scope, the Port Authority decided to establish an on-site team comprised of in-house staff members and members of private consulting organizations to oversee this program. O'Brien-Kreitzberg, program management consultant, together with the planning consultant, F. R. Harris, Inc., and the program architect, I. M. Pei & Partners, report to the Port Authority's program director through the contract manager. A separate manager of design (TAMS/SSVK) and managers of construction (Bechtel Civil, Inc., and Tishman Construction Corporation) round out the on-site program team.

A comprehensive program management plan guides this program under a philosophy of maximizing the decision-making authority under one roof at the lowest possible level. Primary consultants function as extensions of the Port Authority staff in analyzing issues, developing recommendations, and implementing program director decisions. Cross communications between disciplines, consultants, and

contractors is encouraged. O'Brien-Kreitzberg maintains overall coordination responsibility, including the master program schedule.

Planning and design execution is shared among the planning consultant, program architect, manager of design, and architect-engineers (A-Es) hired separately to prepare construction drawings for each project. Engineering and design services can be obtained through "call-in" A-E firms retained by the Port Authority or through individual requests for proposals (RFPs) issued for separate projects. As is the Federal Government, the Port Authority is required to set aside a portion of its work (the target is 15 percent) for small and disadvantaged firms. Awards to A-E firms are based on a weighted point system with cost an up-front consideration. The contract for services parallels the American Institute of Architects (AIA) Document B-141, *Agreement Between Owner and Architect*, list of services.

A multiplier comprising overhead, general and administrative (G&A) cost, and profit is negotiated up-front for all Port Authority A-E contracts, and that multiplier becomes the basis for pricing subsequent work. The average multiplier is approximately 2.65, or 165 percent of the direct labor rate. The fee as a percent of construction varies widely depending upon the amount of work required for each project. If the program architect has accomplished the major portion of the concept design and the criteria is well established, the remaining work for the A-E firm could be limited to the preparation of final construction drawings. Fees would generally be less than 5 percent of the construction cost for that reduced scope of work.

Special Project Features

With the current recession's impact upon the airline industry, JFK 2000 is being restructured, and many projects are being deferred until the economic picture brightens. Airline user fees are the principal source of income for the JFK Airport. This "downsizing" has caused major schedule readjustment and sequencing of designs to ensure compatibility with existing facilities.

In managing design, heavy emphasis is placed on criteria and concept designs to ensure that final designs proceed smoothly. By having decision making under one roof, strong integration of users' requirements and design guidance is achieved. The management team believes a minimum of lost design is encountered with the JFK 2000 projects.

Two formal design reviews are required, one at the 40 to 50 percent stage of design completion, and another at the 85 to 95 percent stage. Since the A-E and the management team have frequent and continual contact during the concept stage, a formal review is not required during that stage. Project cost management is a key focal point during each review.

A separate division within the Port Authority conducts quality assurance reviews and must sign off on the design drawings. Value engineering (VE) is driven by the client requirements. Costs that appear to be growing out of line may signal a requirement to conduct a VE review.

Construction engineering services, including shop drawing review, inspection, and testing, are negotiated up front with an A-E if the services requirements are beyond the capacity or capability of the Port Authority or its management team. Most of these services are typically provided in-house.

MILWAUKEE WATER POLLUTION ABATEMENT PROGRAM

Project Description

Milwaukee's sewage system, unable to handle the combined normal sewage load and storm runoff during periods of heavy rain, was forced either to expand its treatment capacity or to provide a separate sewage system for surface runoff. After studies revealed the more cost-effective solution was to improve the existing system, construction began in 1977 to build new sewage interceptor lines, develop storage for surge capacity, and upgrade the two major treatment plants. Funding for the project is derived from local and state revenues and Environmental Protection Agency (EPA) grants. Overall cost for this program is estimated at $2.1 billion, and the project is about 75 percent complete (in mid-summer 1991).

Client/Architect-Engineer Relationship

The Greater Milwaukee Water and Sewer District, affecting 27 separate communities, has a permanent staff, including an engineering capability, that handles day-to-day operations. The District concluded that the scope of this extraordinary project far exceeded the in-house capacity and retained CH2M Hill to manage the program. That firm operates a project management office (PMO) separate from the District office but has retained about 35 District employees, and

5 to 7 other A-E firm employees have been integrated into the office. The PMO has become an extension of the District office.

The PMO manages acquisition of A-E services. However, selection and award of A-E contracts are subject to District approval. A-E contracts are normally fixed price based on the estimated level of man-hours. A standard District contract form with its own general provisions is the basis for all A-E contracts. The PMO manages the design process which costs about one half percent of the cost of construction. The PMO establishes design criteria, performs most geotechnical and other site surveys, and reviews critical design elements performed by A-Es but does not check each design detail or calculation. Design reviews are conducted at the 40 and 90 percent stages of completion. Projects over $10 million require a VE review; those over $20 million require two VE reviews. A constructability review is conducted by the PMO at the 90 percent completion stage.

Special Project Features

Milwaukee has produced a profitable fertilizer by-product ("Milorganite") from its sludge operations that for years has been an important source of revenue for the District. Keeping production of this product in operation during plant modifications became important. Decisions to ensure continuity of production were made based on overall cost savings. Design and construction plans were adjusted accordingly.

The centerpiece of the project was the construction of 20 miles of 32-foot-diameter tunnels 200 feet below ground to temporarily store the excess sewage until treatment can be rendered at off-peak periods. Another 62 miles of new near-surface interceptor sewers and tunnels are being installed to complete the distribution system.

The availability of funds has been a key issue affecting progress. Delays of several months have occurred when expected funds were not provided although the project appears now to be ahead of schedule.

The PMO has contracted with 88 firms for professional services and has awarded nearly 300 contracts for procurement of professional and construction services. For the total construction cost of $1.62 billion, the design cost has been $127 million or about 7.8 percent. Planning fees were another $78 million and project management costs, including construction oversight, are projected to be

$148 million. Operation of the PMO cost $37 million and real estate costs were $11 million.

PORT EVERGLADES EXPRESSWAY

Project Description

Termed as the most complex construction project ever undertaken by the State of Florida, this highway (I-595) completes the final link of Florida's interstate system. Traversing the densely populated section of Ft. Lauderdale in Broward County, this 13.4-mile project connects I-75 on the west and the Port Everglades/ airport complex at its eastern terminus. The project has 310 "lane miles," 12 miles of connecting roads, 93 bridge crossings including three 4-level interchanges, and 11 other interchanges of either 2- or 3-level bridge structures. The overall project cost is expected to be about $1.2 billion, of which $460 million was estimated for real estate acquisition and $43 million for utilities relocation. The cost for engineering design was $33.6 million or 2.8 percent of program amount (PA), and site construction engineering and inspection cost $52.8 million or 4.4 percent of PA. Exclusive of real estate, the engineering design cost would be 4.5 percent of PA. Federal funds supported 90 percent of the total cost. Construction began in July 1984, and final completion is scheduled for 1991.

Client/Architect-Engineer Relationship

The Florida Department of Transportation (FDOT) was unable to manage a project of this magnitude with its own staff and hired a construction manager led by ICF Kaiser Engineers in joint venture with the Orlando office of Howard Needles Tammen & Bergendoff (HNTB), a consulting engineering firm. This was the first time that a construction management (CM) firm was used to oversee a Federally-funded highway project. HNTB was responsible for integrating overall design into the project and assumed a technical responsibility for FDOT. They conducted reviews of individual design projects, functioning as an extension of the FDOT staff.

Contracts for A-E services were awarded by FDOT using state selection and contracting procedures that are very similar to those specified by the Federal Acquisition Regulation (FAR). Selections are made from lists of prequalified firms with demonstrated capability for the required work. Projects are negotiated on a man-hour basis with overhead rates capped at 141 percent. Ten separate firms,

including HNTB, designed 19 of the 21 projects; FDOT designed the other 2 using their in-house team. Services generally are similar to those suggested by AIA Document B-141, with the design prepared in the three phases of schematic design, design development, and construction documents. Most administrative services are carried as part of the overhead expense; however, additional travel, reproduction, and presentations would be reimbursed as additional services.

Special Project Features

The ICF Kaiser/HNTB team devoted a major amount of time early in construction planning to determine how traffic would be maintained during the 7 years of construction. Sequencing of temporary and permanent roadways and structures became key for establishing design criteria and early schematics. A more traditional method for construction phasing would have been to sequence different segments in a series of independent contracts for design and construction. The tight construction schedule for I-595 would not allow this approach. The CM, after determining the construction phasing, identified the required design projects and, through HNTB, established firm project design schedules.

Because of the changing daily traffic patterns and real estate access and acquisition requirements, the CM and FDOT decided that a proactive community awareness program would be necessary. They established an on-site Community Involvement Program Office and constructed a $70,000 scale model of the project. This program was in operation for more than 4 years and handled 17,000 visitors. The project managers credit this operation toward creating good will within the community and minimizing disruption from uncooperative tenants and motorists.

Real estate acquisition became a major issue during the early stage of the I-595 project. Construction progress was being threatened because of access denied to properties that were to be acquired. This phase of the project, estimated to cost $460 million, overwhelmed the FDOT real estate office. Kaiser offered to assume responsibility for this work, a proposal not universally embraced, but action that was critical to get the project on track. By all accounts, the effort was successful. Kaiser credits the philosophy of having a single manager in charge as the reason for achieving success on this project.

HYPERION ENERGY RECOVERY SYSTEM (HERS)

Project Description

The City of Los Angeles treats 80 percent of its waste water at the Hyperion Waste Water Treatment Plant located along the West Coast adjacent to Los Angeles International Airport. The joint venture of Schneider, Inc./Combustion Power Technologies was selected from a prequalified bidders list to construct a sludge combustion facility using state-of-the-art fluidized bed boilers. SE Technologies, Inc., was the subsidiary consultant to the contractor for engineering and design services.

This design-build project receives sludge dried to 5 percent moisture content and processes it through three fluidized bed combustion trains, at which each recovers 50,000 pounds of steam per hour. This energy is used by the city to run a condensing steam turbine, capable of generating 12 MW of electric power. The process incorporates ammonia injection for nitrous oxide control, wet scrubbers for control of sulphur dioxide, and baghouses for control of particulates. This phase of the $200 million HERS project cost $43 million of which $5 million (11.6 percent) was designated for concept design, process engineering and layout, final plans and specifications, construction training, operator training, operation and maintenance manuals, and startup/testing. Construction was started in 1983 and completed in 1989. SE Technologies is providing continuing on-site engineering support for maintenance, operation, and training.

Owner/Architect-Engineer Relationship

The City of Los Angeles owns the treatment facility; the firms J. M. Montgomery and Ralph M. Parsons are A-E consultants that provide oversight and coordination for all projects within the waste water process. The owner provided flow sheets and specifications which formed the basis for bid proposals. Normally, the city awards contracts to the lowest responsive/responsible bidder; however, for HERS, project technical competence was the overriding factor for award. SE Technologies operated under a contractual arrangement with the contractor providing all engineering and design services. Schedule and cost control performance of SE Technologies was monitored by its parent company; however, of paramount interest was the technical services supporting construction throughout the project. Since

performance of the combustion trains and their pollution controls was the prime goal, SE Technologies' interests were always focused on the process.

Special Project Features

Although plant operation had begun in 1989, full production has not been achieved due to difficulties encountered by the preceding sludge drying stage. The fluidized bed combustion process has not yet brought the intended product to a capacity that will enable the full potential of energy recovery to be realized. This issue is beyond the control of SE Technologies.

State-of-the-art projects require an unusually close bond between the engineers and constructors. The on-site engineering staff shared a field office with the project superintendent and his staff. Problem solving during construction and start-up operation required full team cooperation in order to keep on schedule. Field modifications to equipment occurred often and, in some cases, trial and error techniques were the only way to solve difficult technical problems. The engineering staff believes it was important to document lessons learned because of this first-of-its-kind project. They also stated that while costs for engineering must be monitored, it is of greatest importance that the project costs as a whole be considered. Engineering costs are a necessary investment to ensure that construction costs are kept within reason.

Extraordinary success was achieved with the pollution control devices. Emissions are being maintained at levels far below any standards being contemplated by local jurisdictions. The city believes this project will not encounter pollution violations for many years if the plant is operated following proper procedures.

LOS ANGELES COUNTY LIGHT RAIL SYSTEM

Project Description

The light rail system will connect distant areas of Los Angeles County to provide a mass-transit alternative to the predominately private vehicle mode of the present. In contrast to other forms of rail mass transit, the light rail system takes advantage of existing rail lines, streets, and other public rights of way for its operation. This approach costs less than constructing exclusive rail facilities such as tunnels and elevated structures. The plan for the Los Angeles system provides for

construction over a long period of time, depending upon funds availability and demonstrated success with early rail lines. The north-south Blue Line connecting downtown Long Beach and Los Angeles was opened in 1990. The east-west Green Line currently under construction should open in 1994. It will connect the towns of El Segundo and Norwalk passing by Los Angeles International Airport.

Owner/Architect-Engineer Relationship

The Rail Construction Corporation (RCC) was created as an independent nonprofit corporation for the purpose of constructing the light rail system. It reports to the Los Angeles County Transportation Commission and coordinates engineering, traffic, and related matters with the California Department of Transportation. The RCC has retained O'Brien-Kreitzberg as its CM responsible for construction planning and quality assurance, including the review and approval of shop drawings.

Planning and design is underway for the Red Line that will connect Hollywood with downtown Los Angeles. Scheduled to be constructed in two phases, the Red Line will have much of its railway underground in the densely urban area of downtown Los Angeles. At a programmed cost of $2.9 billion, planners project the engineering and design costs for the Red Line will be 9.6 percent of the construction cost. Projected for completion before the year 2000, it will be difficult to consider the Red Line a "light rail" system because of its heavy investment in construction. Program cost of the Blue Line was $877 million, and the Green Line is estimated to cost $886 million. The average cost of design is projected to be 8.5 percent of the construction cost, exclusive of construction inspection.

Acquisition of A-E services usually follows a two-step process, with a request for quotations (RFQ) followed by a RFP. Of the contracts awarded by the RCC, 23 percent have gone to disadvantaged businesses. Price negotiations are based on hours by discipline, and overhead and fees are capped. The RCC, similar to California's public agencies, generally follows the FAR as a guideline for its contracting procedures.

Design reviews are conducted at the 30, 60, and 85 percent stages. Local communities are invited to participate in the reviews. However, their primary interest lies in the actual design of the stations and landscaping.

Special Project Features

One of the unique features of the light rail project is its planning horizon. A 1/2 percent sales tax has helped to ensure funding for the near term. However, the full extent of the system and its completion date are less than certain. Each line is being constructed virtually as a stand-alone entity. Although the RCC was created to oversee the metrorail system, each rail line appears to be programmed and managed independent of the next project. Perhaps the most graphic example of this is manifested in the different rail gauge between the Blue and Green Lines. Different equipment will be operating on each line and will require unique and separate maintenance facilities, which will necessitate separate parts supply and training programs for the Blue and Green Lines. Los Angeles County has no assurance that the future lines will be compatible with either of the first two. The reasons for this unusual arrangement are not clear but appear to be rooted in the county's political structure.

Operational s artup of the Blue Line was managed carefully to help ensure success. Authority and funds were given to a trouble-shooting/indoctrination team to solve any technical, traffic, fare, and vehicle problems and resolve customer complaints on the spot, during start up of the rail service. This worked extremely well in making the service attractive to patrons and generating a positive feeling about the new rail line.

APPENDIX J

STATISTICAL ANALYSIS TO DETERMINE MANPOWER FORECASTING MODEL COEFFICIENTS

STATISTICAL ANALYSIS TO DETERMINE MANPOWER FORECASTING MODEL COEFFICIENTS

INTRODUCTION

Data for each of the following U.S. Army Corps of Engineers (USACE) components were assembled for inclusion in the manpower forecasting model:

- Division Office Staffing
- District Support Staffing
- District Construction
- District Engineering
- District Direct Engineering
- District Field Construction Offices.

For Division Office staffing, FY85 data on design and construction placement and man-years were utilized, supplemented by data on field operating activity (FOA) factors relevant to Division offices. Therefore, each Division's placement, staffing, and FOA factor value represented an observation for analysis: all Division observations were combined into a data file for statistically determining forecasting model coefficients for Division support.

For District Support staffing, FY85 data on design and construction placement and staffing were utilized and were also supplemented by data on FOA factors relevant to District offices. Each District's placement, staffing, and FOA factor value comprised an observation for analysis; all District observations were combined into a data file for statistical derivation of District Support staffing model coefficients. Analysis of technical indirect staffing (that does not charge directly to specific projects) at the District level was segregated into District Construction and District Engineering.

Individual projects were used as the units of observation for District Direct Engineering staffing requirements. Data were obtained on programmed amount and staff hours charged for sampled projects within each fund type from "field data calls"

conducted in October and November 1986. Separate data analysis files were created for each fund type (see Table J-1 for a fund type listing), and model coefficients were determined for each group.

TABLE J-1

FUND TYPE LISTING

Fund	Type listing
MCA	Military Construction, Army
MCAR	Military Construction, Army Reserve
MCAF	Military Construction, Air Force
MCNM	Military Construction, Navy and Marine Corps
MILCON-Other	Military Construction, Other
OMA	Operations & Maintenance, Army
OMAR	Operations & Maintenance, Army Reserve
OMAF	Operation & Maintenance, Air Force
FHA	Family Housing, Army
FHAF	Family Housing, Air Force
PBS	Production Base Support

Field construction offices were used as the units of observation for District Field Construction Offices. Data on placement and staffing for each fund type, augmented by FOA factor values for each field office, for FY84, FY85, and FY86 were obtained through field data calls. Separate data files were created and analyzed for each fund type with each field office's placement, staffing, and relevant FOA factor values included.

We used multivariate linear regression analysis to derive the relationship between workload, staffing, and relevant FOA factors for each of these model segments. Workload was measured either as programmed amount (adjusted to reflect placement by removing contingencies), engineering during construction (EDC), or engineering not related to construction (ENRC). In all cases, the dollar values were adjusted to FY85 constant dollars to maintain interyear data comparability. The statistical results for individual model segments follow.

The basic multivariate model used in the regressions was:

$$Staffing = c + a(Wkld) + b(Wkld)^2 + d(FOA) + e$$

where:

- c = a constant term that reflects the nonvariable portion of staffing in each model,
- a = staffing increases with increases in workload (Wkld) above the nonvariable component c,
- b = economies of scale achieved with larger workload levels (giving a slightly curved relationship between staffing and workload as shown in Figure J-1),
- d = the effect of an FOA factor (e.g., the number of active construction projects as a percentage of placement) on staffing independent of the effect of workload on staffing, and
- e = an error term that accounts for random variation in staffing unaccounted for by workload and FOA factors.

DIVISION OFFICE STAFFING

Division Office staffing (man-years) was regressed against engineering placement, engineering placement squared (i.e., the scale effect), and several FOA factors. None of the FOA factors proved to have a statistically significant effect on staffing *independent* of workload. In arriving at this conclusion, we followed a careful process to examine the potential impacts of any FOA factors. First, we ran correlations (simple linear regressions) between the FOA factors and staffing to look for potential relationships. Only a few had a statistically significant relationship. Next, we normalized each of the FOA factors by dividing each factor by Division workload [some factors, such as Outside CONUS (OCONUS), were already normalized on workload and were left intact]. This procedure ensured that the FOA factor measured the effects of staffing that are independent of the size of the workload. Multivariate linear regressions were then run with workload, the scale factor, and the normalized FOA factors in the same equation. In this final step, only the workload variable was significantly related to staffing. Neither the scale factor nor the FOA factors was statistically significant.

The constant, c, was determined to be 39.33, and the variable coefficient for workload, a, was determined to be 0.1703. We used those values in the manpower

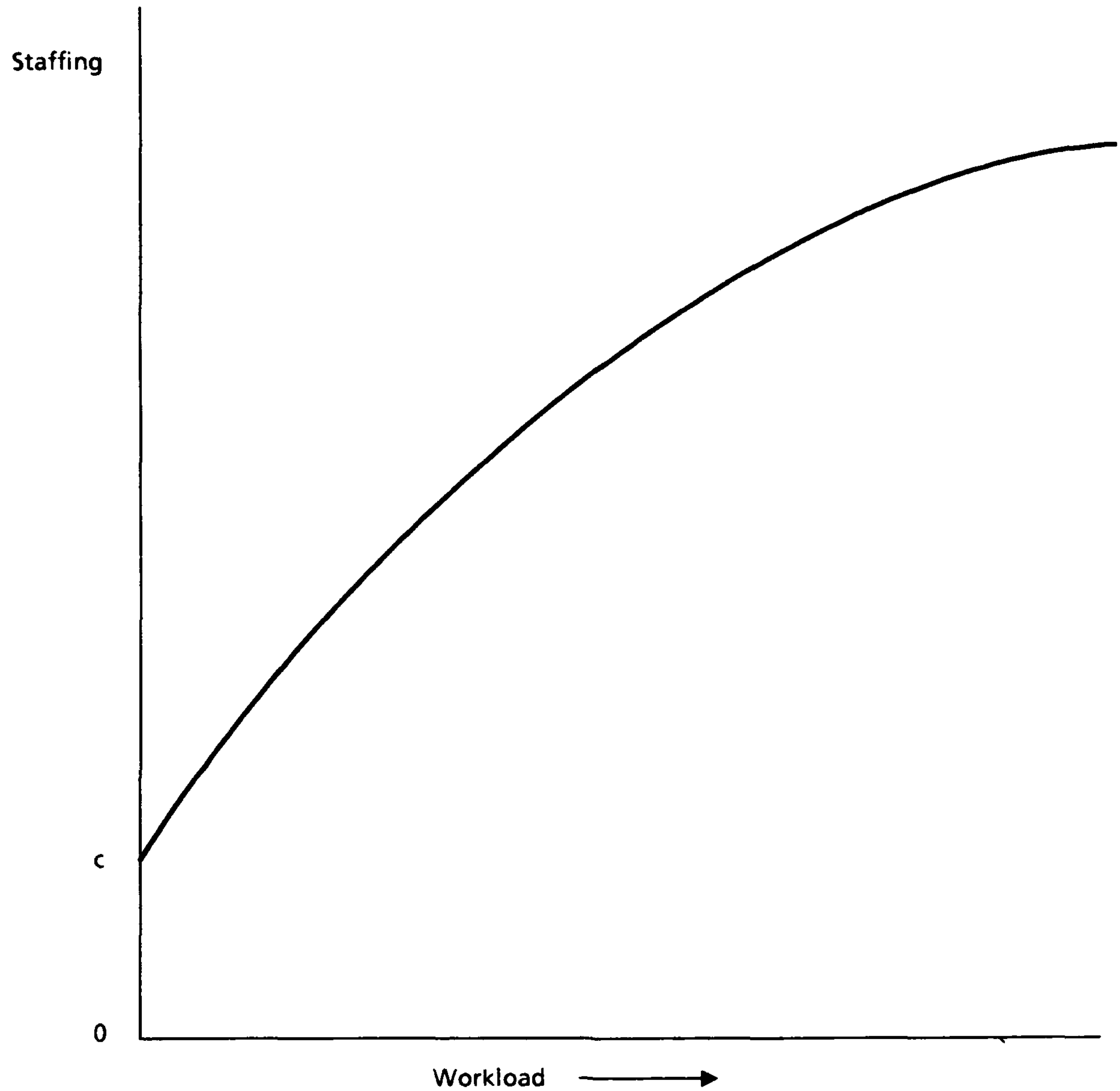


FIG. J-1. ECONOMIES OF SCALE IN STAFF UTILIZATION AS WORKLOAD INCREASES

requirements forecasting model for Division Office staffing. The final regression results for Division Office staffing are shown in Table J-2.

DISTRICT STAFFING

Analysis at the District level was separated into District Construction, District Engineering, and District Support staffing components, and separate regressions

TABLE J-2

DIVISION OFFICE STAFFING REGRESSION RESULTS

Dependent variable – man-years		
Explanatory variable	Coefficient	t-statistic
Constant	39.33	2.695
Design placement (in millions)	0.1703	3.510
Adjusted R-squared (proportion of variation explained by model)	0.654	
F-statistic	12.32	

were run for each component. Actual 1985 man-years for each component were used as the measures of staffing. Design placement provided the measure of workload. The same process used in the Division analysis to search for statistically significant FOA factors was utilized in the District analysis. No economies-of-scale effect was discerned for construction support. The constant (nonvariable) amount of construction support was determined to be 0. The model coefficient for design placement was determined to be 0.2376 man-years per $1 million of design placement. The regression results for District Construction Staffing are shown in Table J-3.

District Engineering staffing proved to be a function of engineering placement only; the scale effect and FOA factors had no significant relationship with staffing independent of engineering placement. The nonvariable component was also determined to be zero. The coefficient for engineering placement was 0.1187 man-years per $1 million of engineering placement. The regression results for District Engineering staffing are also presented in Table J-3.

District Support Staffing, like District Engineering, had only one statistically significant variable – total engineering and construction placement. Neither the scale effect nor any of the FOA factors bore a significant relationship to staffing independent of engineering placement, and the nonvariable component was also determined to be 0. The coefficient for design placement was 0.2402 man-years per

TABLE J-3

DISTRICT STAFFING REGRESSION RESULTS

Explanatory variable	Coefficient	t-statistic
District Construction (Dependent variable = man-years)		
Construction placement (in millions)	0.2376	9.04
Adjusted R-squared	0.85	
F-statistic	81.73	
District Engineering (Dependent variable = man-years)		
Engineering placement (in millions)	0.1187	4.91
Adjusted R-squared	0.12	
F-statistic	24.11	
District Support staffing (Dependent variable = man-years)		
Total (engineering and construction) placement (in millions)	0.2402	7.40
Adjusted R-squared	0.78	
F-statistic	54.76	

$1 million of engineering placement. Table J-3 shows the regression results for District Support staffing.

DISTRICT DIRECT ENGINEERING

District Direct Engineering was the subject of intensive data collection and analysis efforts focused on a large sample of individual projects from all of the USACE offices. The procedure began by obtaining a computerized data file from the Automated Management Project Reporting System (AMPRS) data base of all design projects that started in FY80 or later. That file was first divided into two files, one for

projects designed in-house and the other for projects contracted to architectural and engineering firms. Both of these files were then subdivided into the 13 fund types used by the model. The projects in each fund type were then sorted in ascending order of programmed amount and divided into quartiles, with 25 percent of a fund type's projects in each quartile. Thirty projects from each quartile were randomly selected.

We used the procedure of selecting a stratified random sample based on size of programmed amount for two reasons. First, many fund types have a relatively small number of large projects, and simple random sampling would have included very few large projects. Second, and most important, we believe that the relationship between staffing and programmed amount is not a constant linear proportion throughout the entire range of projects; in particular, we wanted to allow for the possibility of economies of scale in staff utilization for large projects. An appropriate sampling scheme under these conditions is a stratified random sample based on the size of programmed amount, thus ensuring appropriate representation of all sizes of projects in the sample.

The AMPRS data base provided information on the programmed amount for each sampled project but not direct charge man-hours. We, therefore, sorted the sampled projects for each fund type according to Districts and mailed lists of those sampled project numbers, by fund type, to each District office. Districts were requested to query their Corps of Engineers Management Information System (COEMIS) data bases and send in the total direct charge man-hours for each project, and those man-hours were keyed into the data files for analysis. More than 1,000 design projects were analyzed.

In regressions for District Direct Engineering, we used project man-hours as the variable to be explained (i.e., the dependent variable) and the programmed amount of the projects as the explanatory (i.e., independent variable). Separate regression equations were estimated for each fund type, for both in-house and A-E efforts. The regression results for District Direct Engineering showing the nonvariable (or constant) amounts, coefficients for programmed amount, and the adjusted R-squared (i.e., the proportion of total variation in work-years explained by the regression models) are presented in Tables J-4 and J-5.

TABLE J-4

IN-HOUSE DESIGN STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours				
	Constant	Program amount coefficient	t-statistic	Adjusted R-squared	F-statistic value
MCA	2,512	1,125.80	8.28	0.45	68.52
MCAR[a]	2,512	1,125.80	8.28	0.45	68.52
MCAF	4,316	727.90	4.03	0.19	16.20
OMA	343	885.50	7.08	0.54	50.19
OMAF	388	474.50	3.56	0.26	12.71
FHA	803	97.90	7.21	0.52	52.03
FHAF[b]	803	97.90	7.21	0.52	25.81
PBS	243	1,197.90	6.47	0.57	41.92
Other	1,007	493.60	5.78	0.38	33.38

[a] Regression equation not significant, use MCA results.

[b] Regression equation not significant, use FHA results.

DISTRICT FIELD CONSTRUCTION OFFICES

All of the data for analyzing District Field Construction Office staffing came from the September 1986 field data call. In that data call, we asked Districts to provide figures on Field Construction Office man-hours charged, total placement, and other FOA factors for each of the 11 fund types for FY84 through FY86. Further, these data were requested separately for each Area Office within each District. Average 3-year values for each variable for each office became the observations used in the final analyses.

Regression analyses utilized direct man-hours charged to construction projects to individual Area Offices as the variable to be explained (i.e., the dependent variable), and total placement in individual Area Offices as the primary explanatory (i.e., independent variable). In addition, total placement squared was introduced to identify any economies of scale in large construction projects, and the FOA factors were included for potential effects on man-hours.

TABLE J-5

A-E DESIGN STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours				
	Constant	Program amount coefficient	t-statistic	Adjusted R-squared	F-statistic value
MCA	1,090	296.70	9.31	0.38	86.72
MCAR	602	726.70	4.44	0.22	19.70
MCAF	1,222	160.70	5.84	0.33	34.06
OMA	195	334.50	9.27	0.32	85.92
OMAF	147	99.20	3.05	0.12	11.60
FHA[a]	47	409.60	4.34	0.30	18.80
FHAF[b]	47	409.60	4.34	0.30	18.80
PBS	639	267.90	9.60	0.60	92.15
Other	562	191.30	4.87	0.22	23.75

[a] Regression equation not significant, use MCA results.

[b] Regression equation not significant, use FHA results.

The same process for identifying potentially important FOA factors in Division Office and District Support staffing was also followed in the analyses of District Field Construction Office staffing. None of the FOA factors yielded a statistically significant effect on man-hours independent of the effect of total placement.

The complete final regression results for each construction fund type are shown in Table J-6. The percentage of variation in man-hours accounted for by the placement factors varies from 55 percent (OMA) to 88 percent (MCA) – relatively high explanatory power for cross-section data.

CONCLUSIONS

The sampling and data analysis techniques utilized to generate the coefficients for the manpower forecasting and prototype allocation models were appropriate for the objectives of the study. The stratified random sampling of design projects from the universe of projects begun since 1980 provided representative data for all types and sizes of projects.

TABLE J-6

CONSTRUCTION STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours				
	Constant	Total placement coefficient	t-statistic	Adjusted R-squared	F-statistic value
MCA	–79.65	1,700	21.19	0.88	448.93
MCAR[a]	–79.65	1,700	21.19	0.88	448.93
MCAF	3,846.14	1,100	12.20	0.73	148.86
OMA	4,354.07	1,200	6.60	0.55	43.57
OMAF	1,659.38	1,200	6.08	0.65	36.96
FHA	481.36	1,400	16.31	0.84	265.94
FHAF[b]	481.36	1,400	16.31	0.84	265.94
PBS[a]	–79.65	1,700	21.19	0.88	448.93
Other[a]	–79.65	1,700	21.19	0.88	448.93

[a] Regression equation not significant, use MCA results.

[b] Regression equation not significant, use FHA results.

The primary factors for explaining/predicting staffing in District Offices were program mix (i.e., fund type), size of workload (i.e., programmed amount or placement), and economies of scale of larger workloads.

When placed into the USACE manpower forecasting model, the analytical regression results performed extremely well. The total manpower requirement estimated by Corps of Engineers Resource and Military Manpower System (based on actual workload) was within 1 percent of the 8,700 man-years utilized by USACE in 1989. These results are particularly convincing in view of the significant changes in USACE military program and staffing levels that year.

APPENDIX K

STATISTICAL ANALYSIS TO DETERMINE PLANNING AND DESIGN MODEL COEFFICIENTS

STATISTICAL ANALYSIS TO DETERMINE PLANNING AND DESIGN MODEL COEFFICIENTS

Data for planning and design (P&D) costs and construction costs were obtained from the Automated Management and Progress Reporting System (AMPRS). Individual projects were used as the units of observation for P&D funding requirements. Separate model coefficients were estimated for 16 project categories (see Table K-1 for project category listing).

TABLE K-1

PROJECT CATEGORY LISTING

Project category	Category codes	Fund types
Airfield pavements	11X	MILCON, O&M
Training facilities	17X	MILCON
Maintenance facilities	21X	MILCON
Other MILCON (Category codes 100 - 300)	Other 1XX, 2XX, 3XX	MILCON
Supply facilities	4XX	MILCON
Hospital and medical facilities	5XX	MILCON
Administrative facilities	6XX	MILCON
Unaccompanied personnel housing	72X	MILCON
Family housing (new construction)	71X	FH
Other family housing	71X	FH
Utilities and grounds improvements	8XX	MILCON, FH
Other MILCON (Category codes 700, 900)	Other 7XX, 9XX	MILCON, NAF
Hospital and medical maintenance	5XX	O&M
Unaccompanied personnel housing maintenance	72X	O&M
Utilities and grounds maintenance	8XX	O&M
Other operation and maintenance	All other	O&M

Note: Category codes are delineated in Army Regulation 415-28. MILCON Military Construction; FH = Family Housing; NAF = Non appropriated Fund.

We used linear regression analysis to derive the relationship between program amount (PA) and P&D costs for each of these project categories. The PAs were converted to FY91 constant dollars to adjust for inflation, and P&D costs were converted to FY89 constant dollars. The statistical results for the model follow.

The basic model used in the regression was:

$$P\&D = a(PA)^{1/2} + b(PA)$$

where:

$P\&D$ = planning and design costs in thousands of 1989 dollars.

a, b = estimated coefficients.

PA = Program amount in millions of 1991 dollars.

The intercept term was assumed to equal 0 (i.e., *P&D* was assumed to equal 0 when *PA* was equal to 0); this assumption was supported by additional testing of alternative models. The regression results are shown in Table K-2, and the regression statistics are shown in Table K-3.

From the regression results, we developed the P&D rate curves presented in Figure K-1. (Note: For each project category, the curves were capped at a maximum effective P&D rate of 50 percent.)

TABLE K-2

P&D REGRESSION RESULTS

Project category	Coefficient a	Coefficient b
Airfield pavements	55.391	23.529
Training facilities	77.584	46.747
Maintenance facilities	94.454	36.800
Other MILCON (Category codes 100 - 300)	100.366	29.549
Supply facilities	159.941	0.000
Hospital and medical facilities	184.321	36.200
Administrative facilities	210.097	0.000
Unaccompanied personnel housing	127.177	12.698
Family housing (new construction)	37.212	0.000
Other family housing	42.979	14.413
Utilities and grounds improvements	106.281	19.977
Other MILCON (Category codes 700, 900)	114.181	0.000
Hospital and medical maintenance	31.467	36.816
Unaccompanied personnel housing maintenance	49.620	0.000
Utilities and grounds maintenance	40.996	13.472
Other operation and maintenance	51.986	0.000

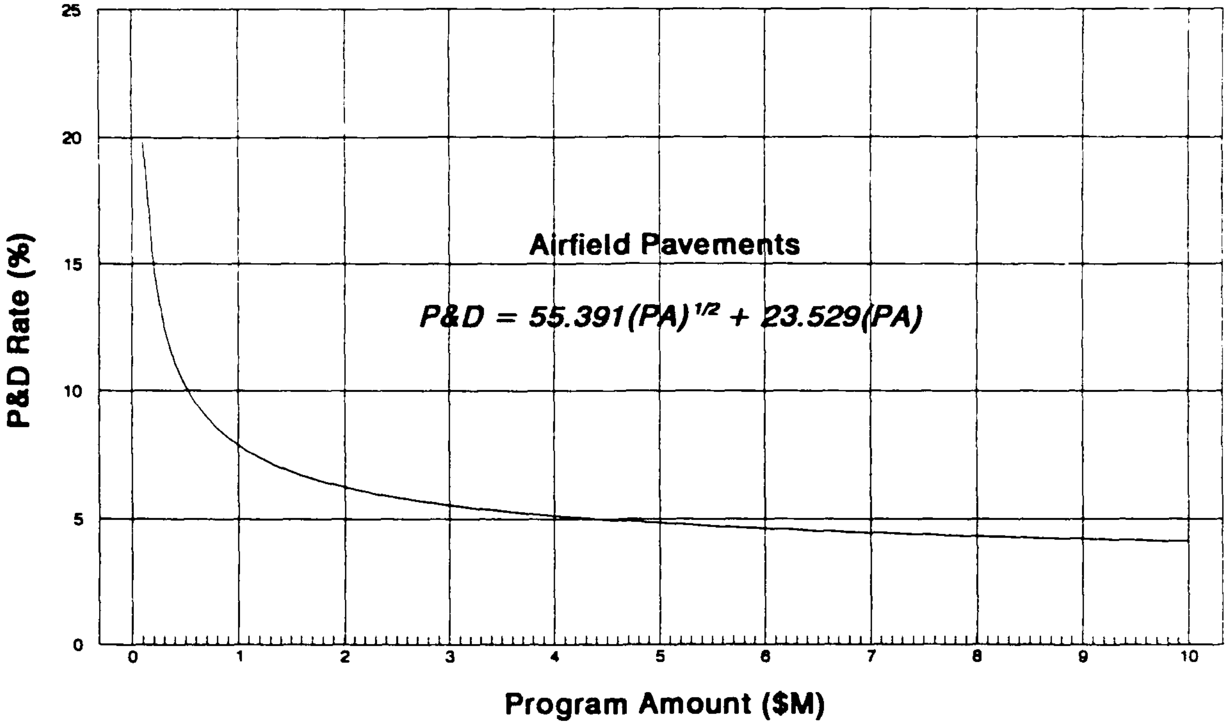
Note: Category codes are delineated in Army Regulation 415-28. MILCON = Military Construction

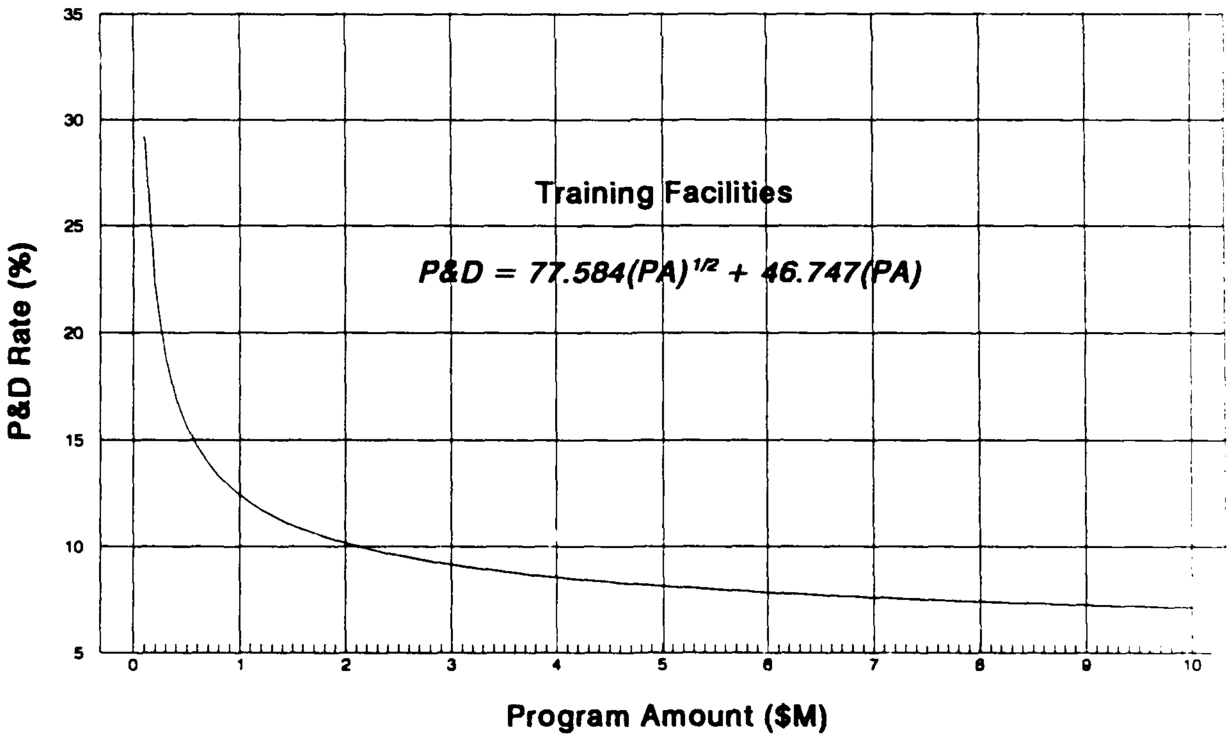
TABLE K-3

P&D REGRESSION STATISTICS

Project category	t-statistic coefficient a	t-statistic coefficient b	Adjusted R-square	F-statistic
Airfield pavements	5.1	5.3	0.75	220.4
Training facilities	4.4	8.3	0.84	546.4
Maintenance facilities	7.1	8.5	0.86	909.2
Other MILCON (Category codes 100-300)	8.5	90.7	0.75	723.3
Supply facilities	18.8	NA	0.69	352.7
Hospital and medical facilities	2.8	2.3	0.89	120.9
Administrative facilities	14.2	NA	0.69	201.6
Unaccompanied personnel housing	7.6	2.6	0.77	382.3
Family housing (new construction)	7.3	NA	0.64	52.6
Other family housing	6.2	4.4	0.70	386.1
Utilities and grounds improvements	8.8	5.6	0.76	458.8
Other MILCON (Category codes 700, 900)	24.3	NA	0.70	591.4
Hospital and medical maintenance	3.7	4.2	0.89	231.4
Unaccompanied personnel housing maintenance	15.5	NA	0.68	240.5
Utilities and grounds maintenance	7.4	3.0	0.65	291.2
Other operation and maintenance	28.2	NA	0.60	796.0

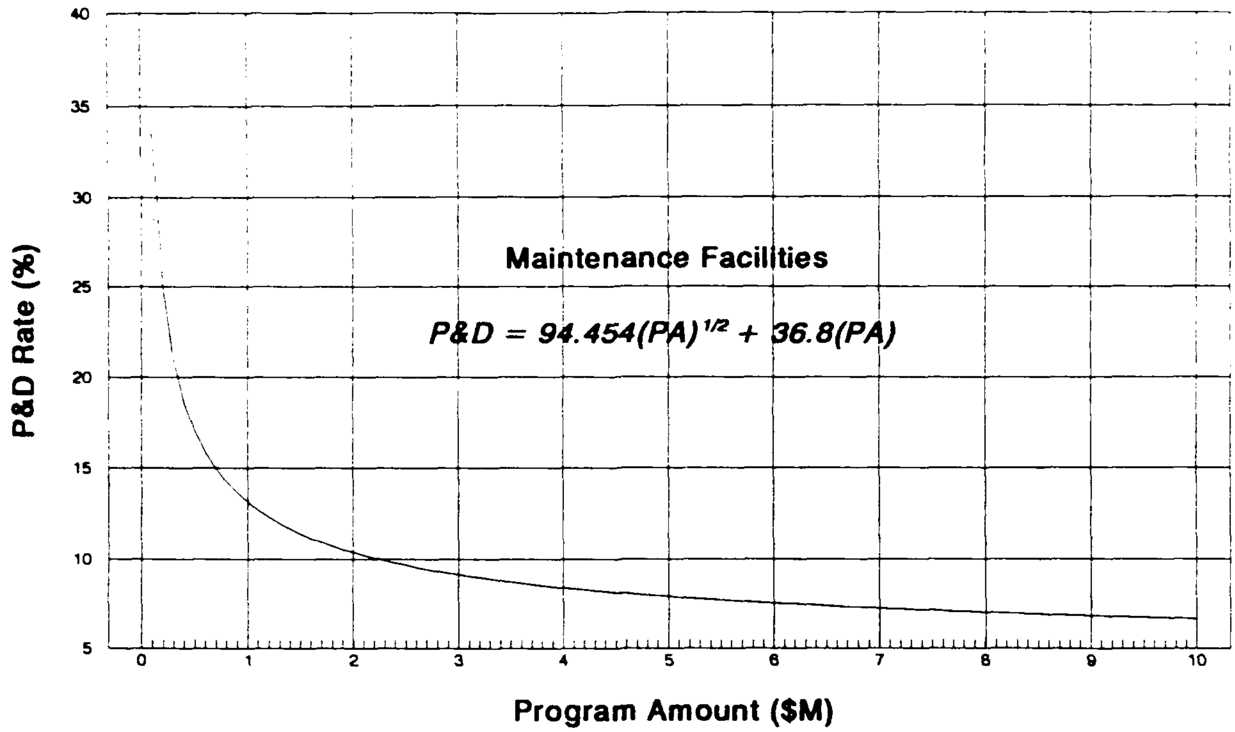
Note: NA = Not applicable.

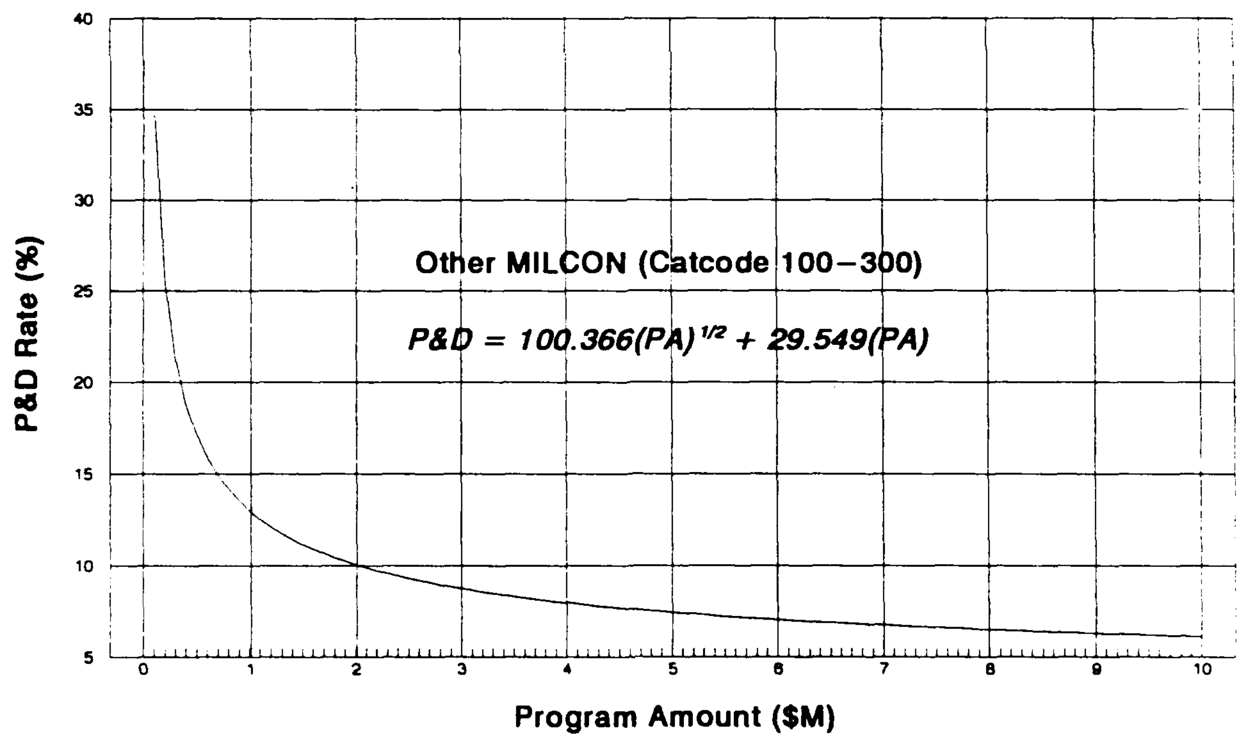




NOTE: Program amount is in 1991 dollars.

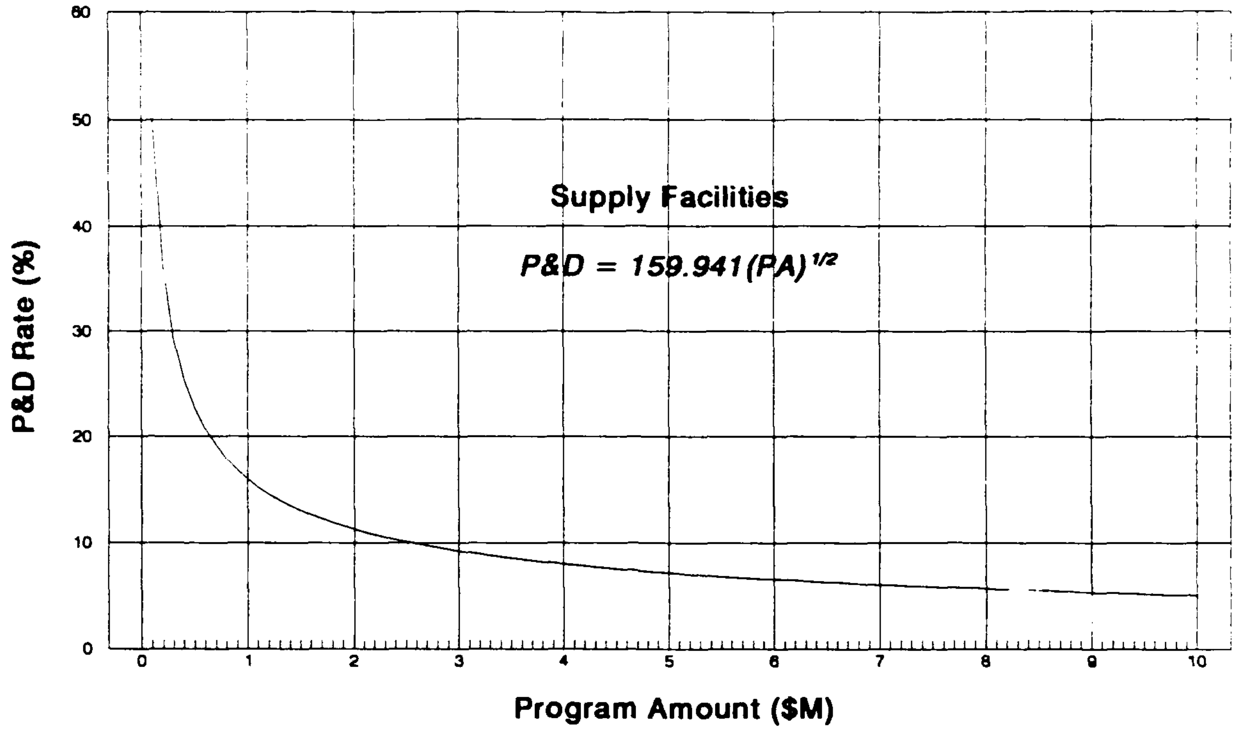
FIG. K–1. P&D RATE CURVES

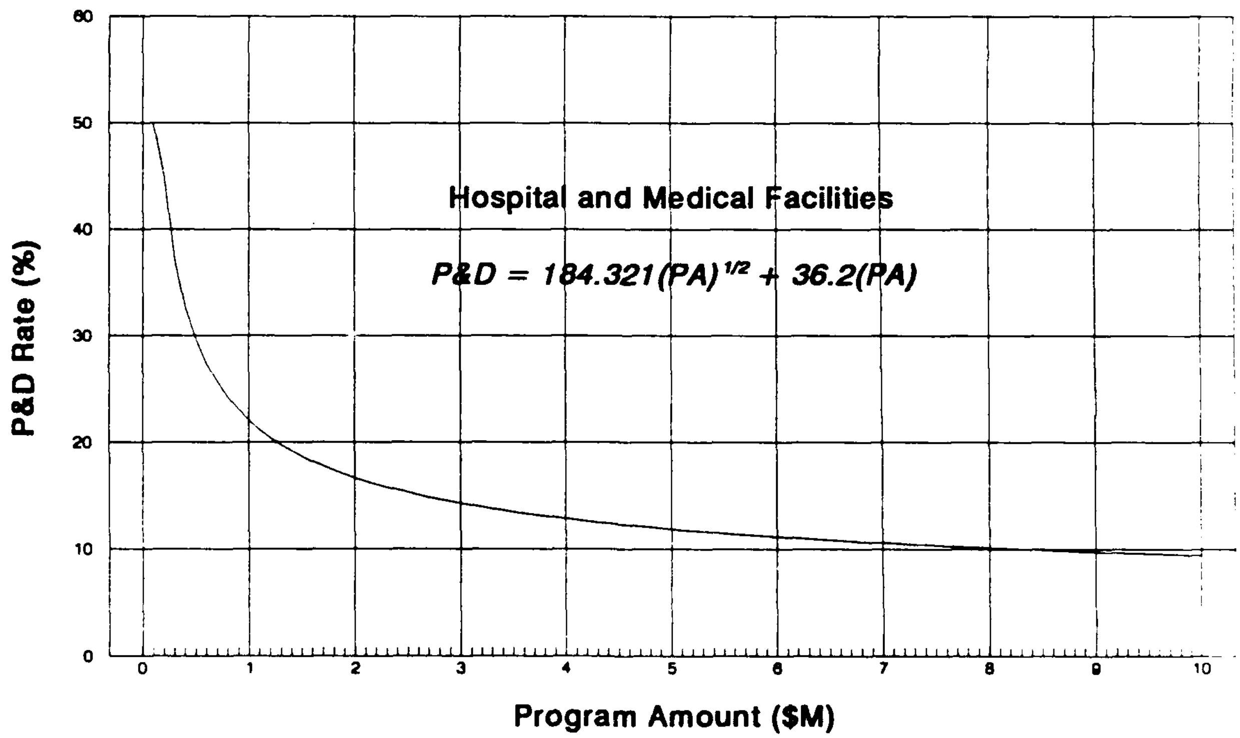




NOTE: Program amount is in 1991 dollars.

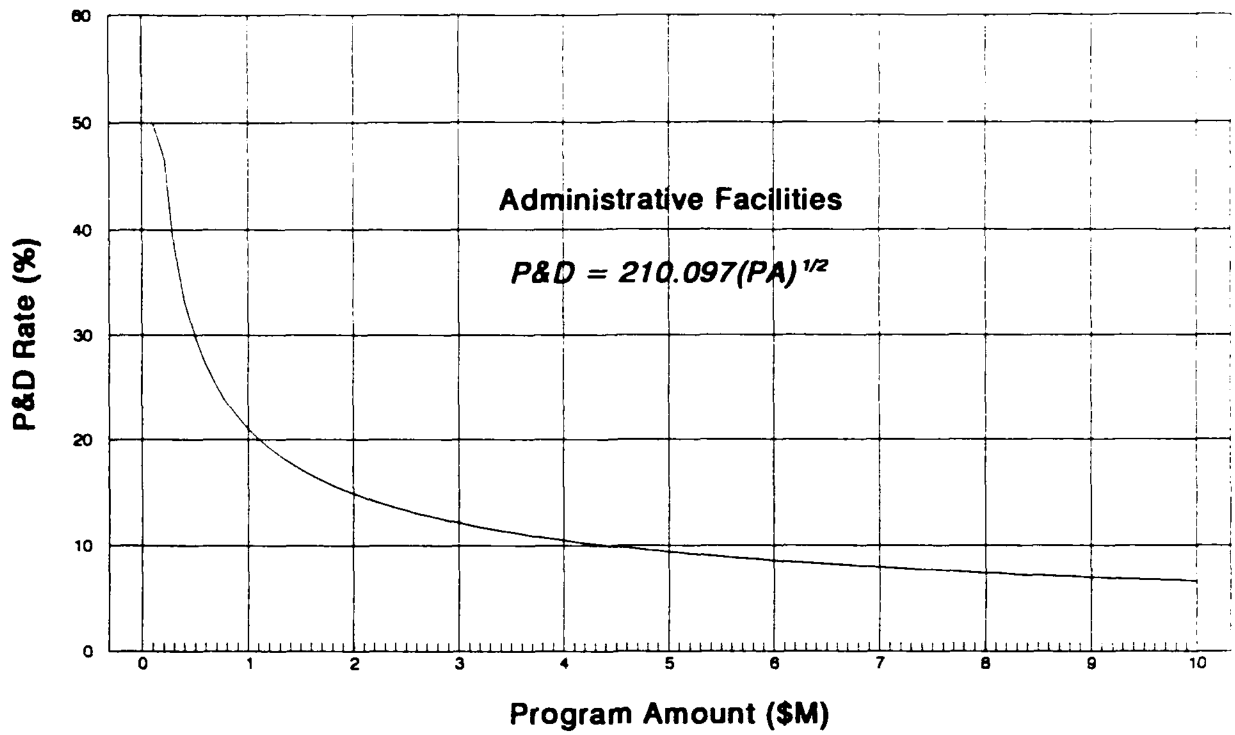
FIG. K-1. P&D RATE CURVES (Continued)

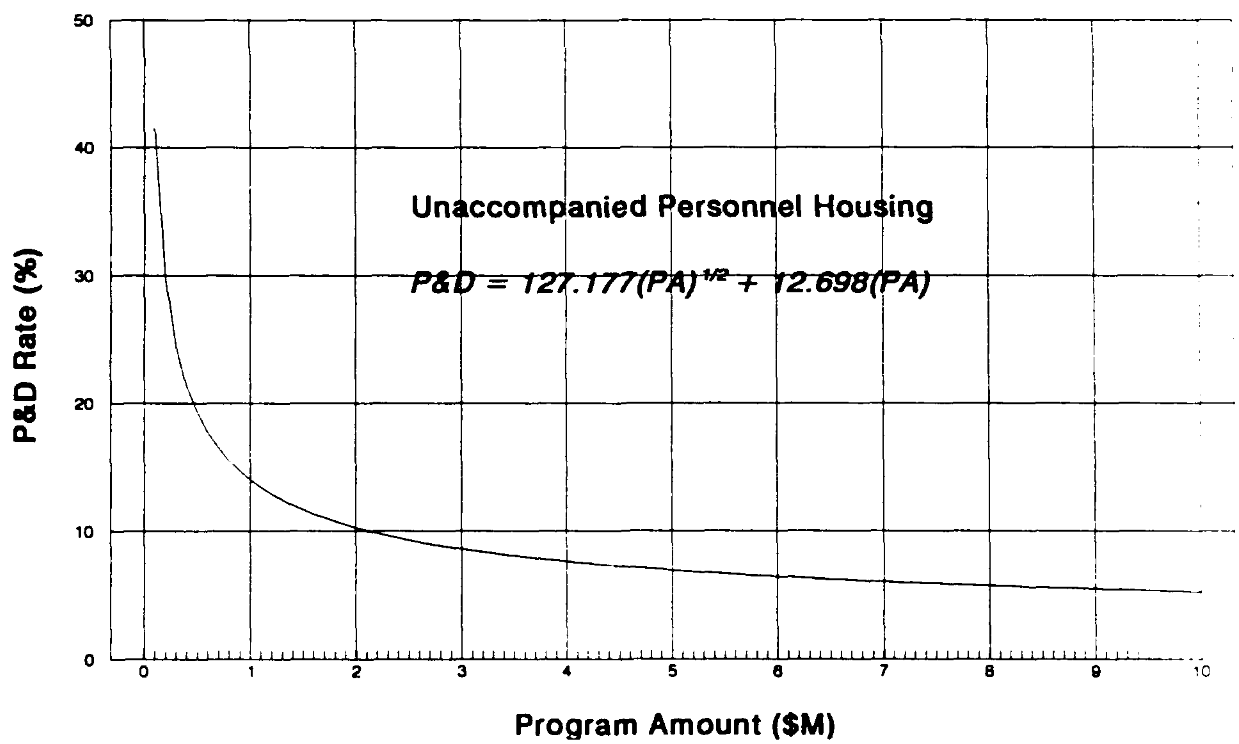




NOTE: Program amount is in 1991 dollars.

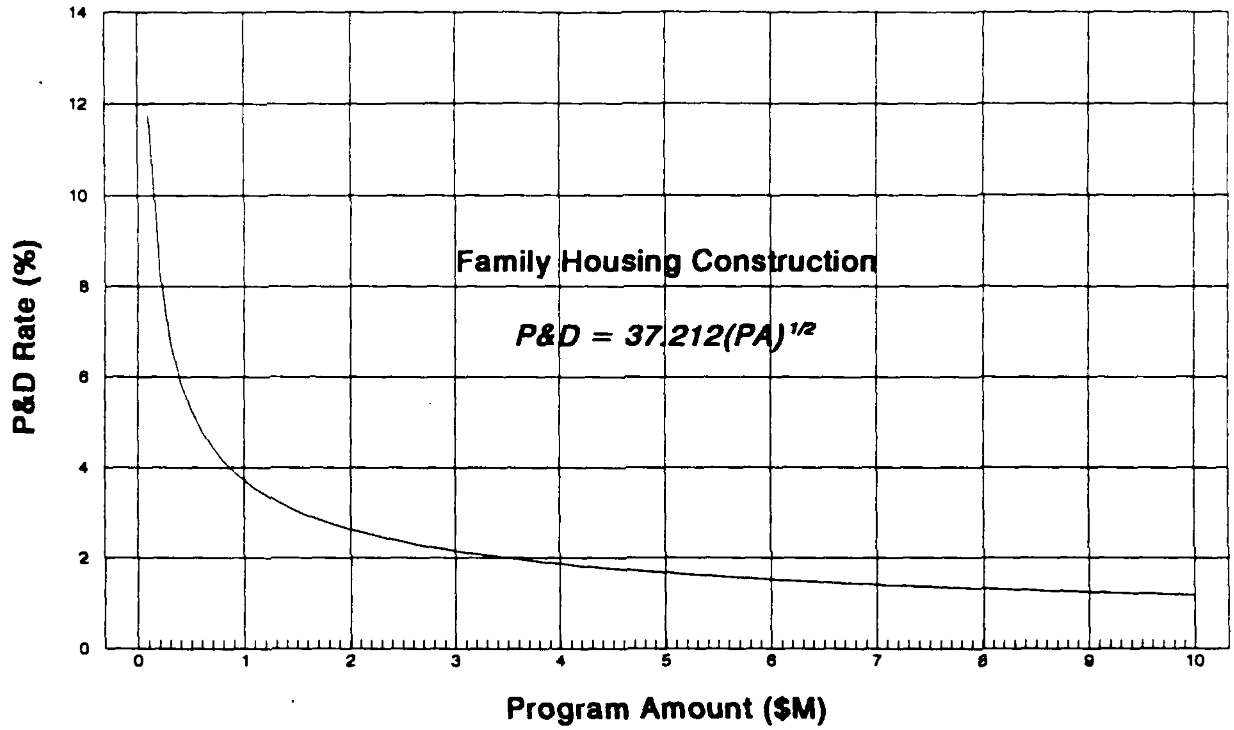
FIG. K–1. P&D RATE CURVES (Continued)

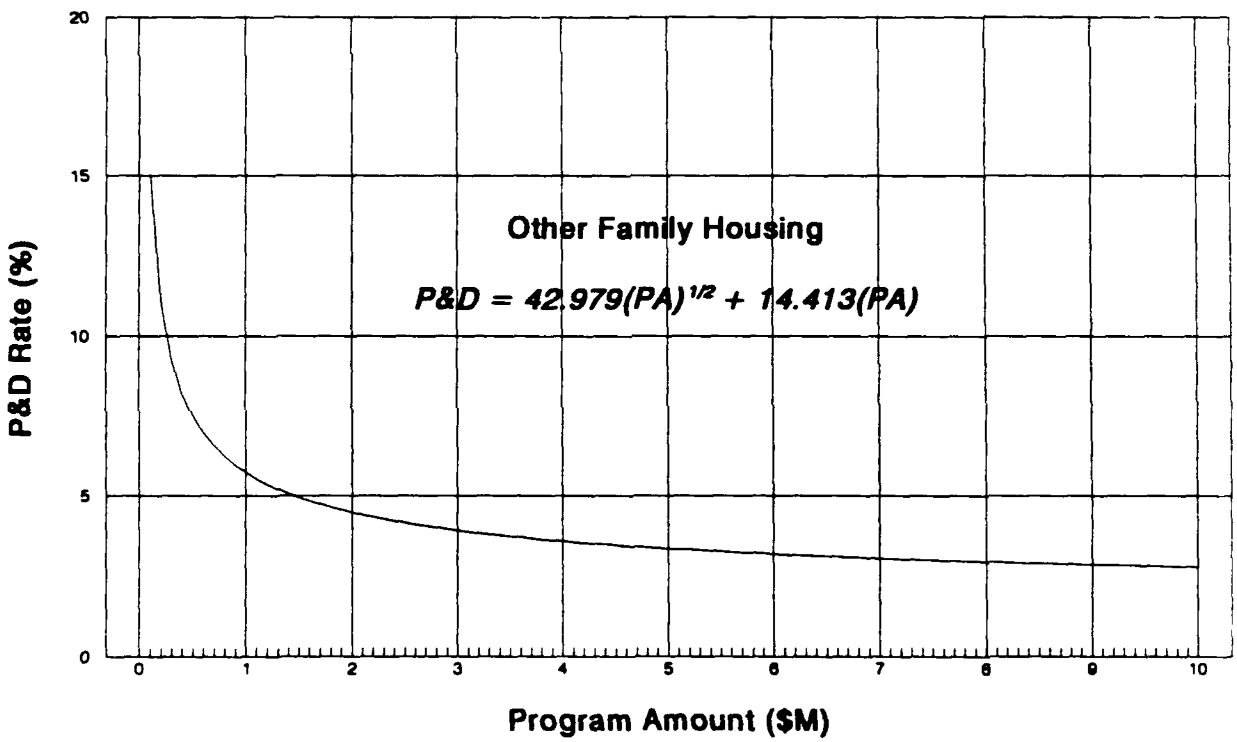




NOTE: Program amount is in 1991 dollars.

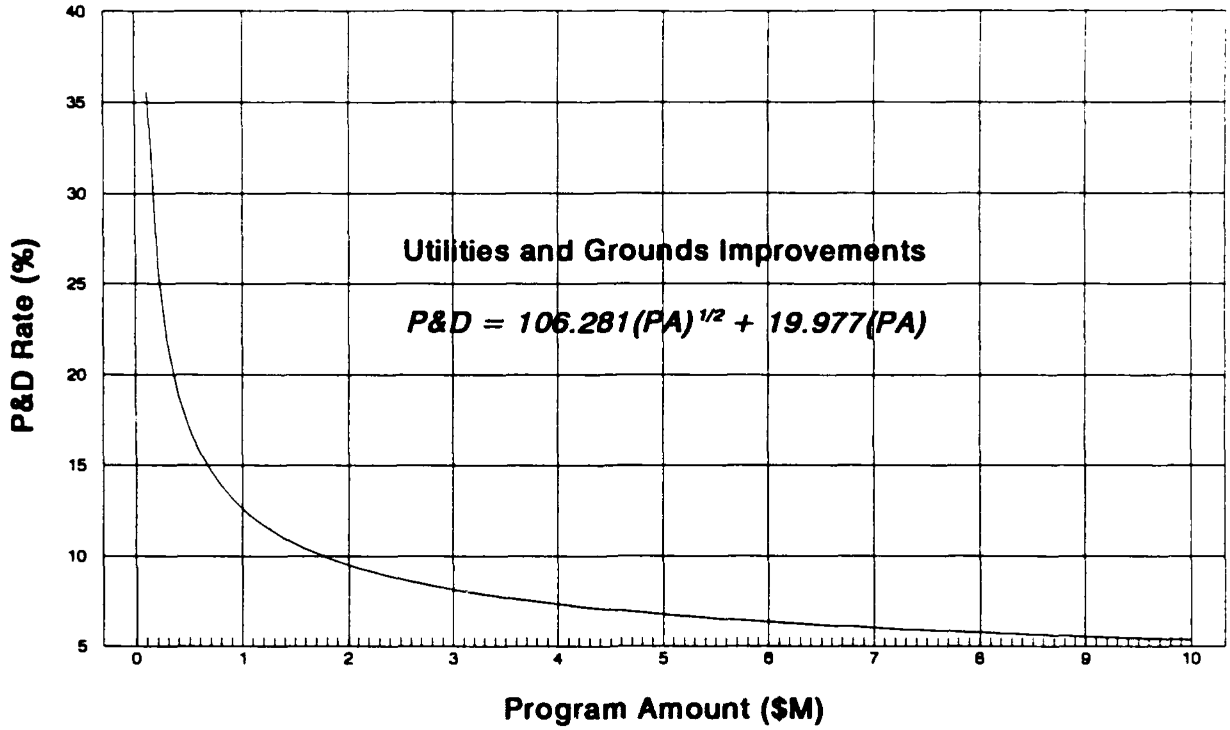
FIG. K-1. P&D RATE CURVES (Continued)

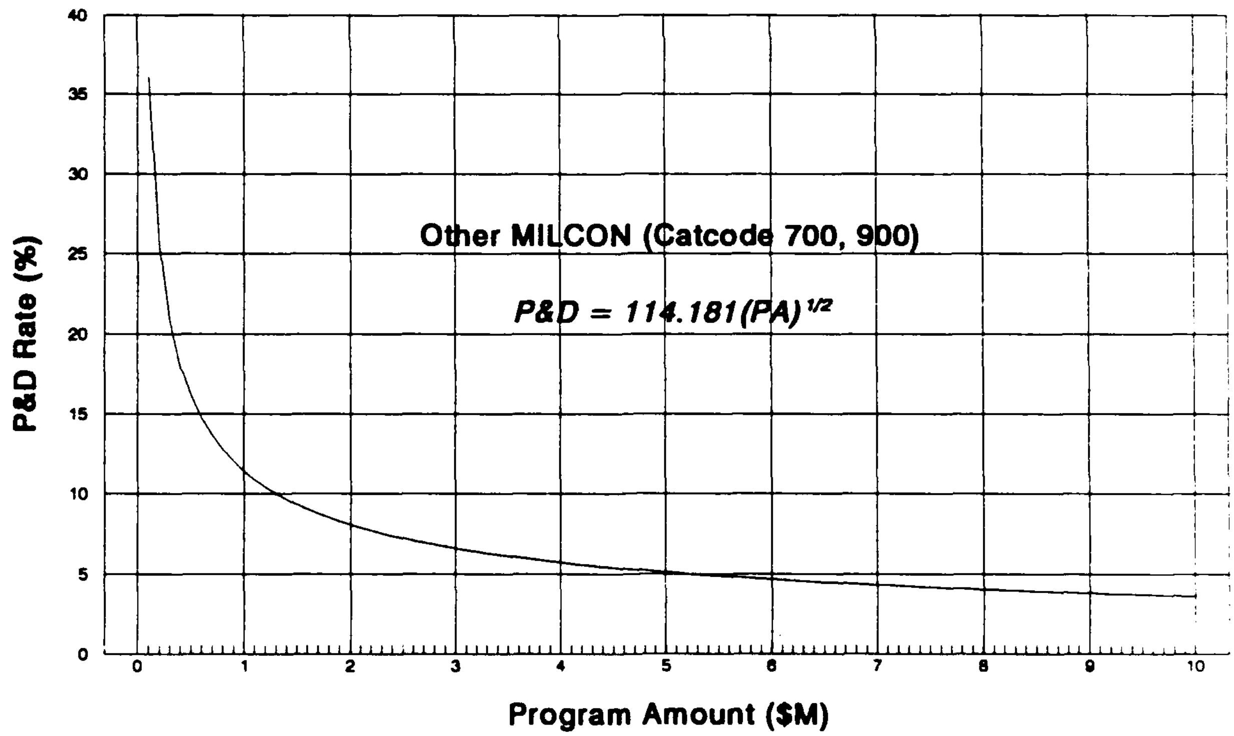




NOTE: Program amount is in 1991 dollars.

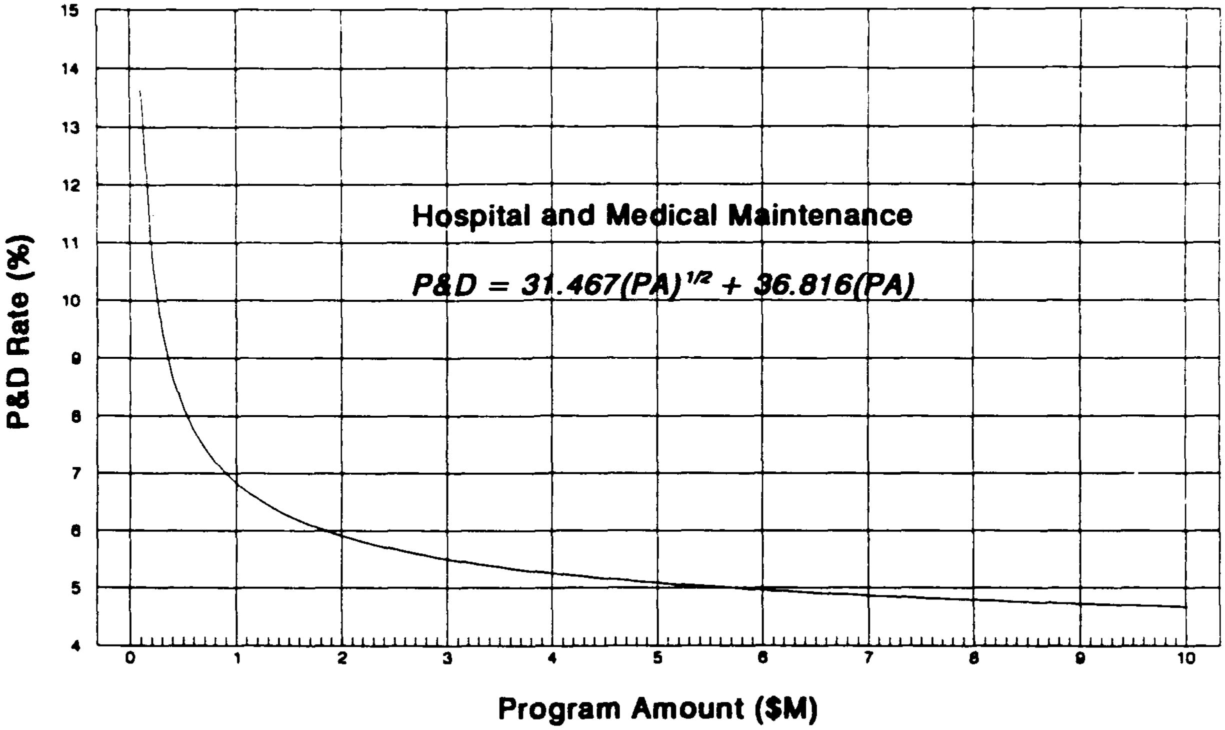
FIG. K–1. P&D RATE CURVES (Continued)

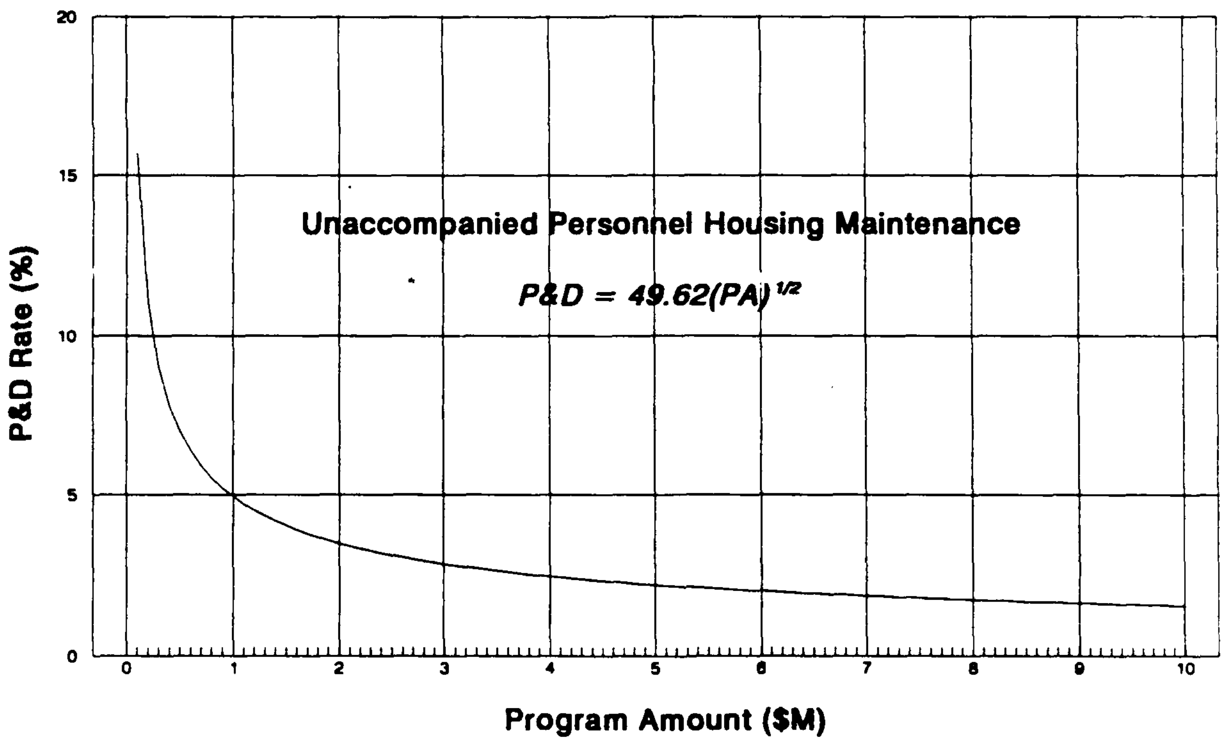




NOTE: Program amount is in 1991 dollars.

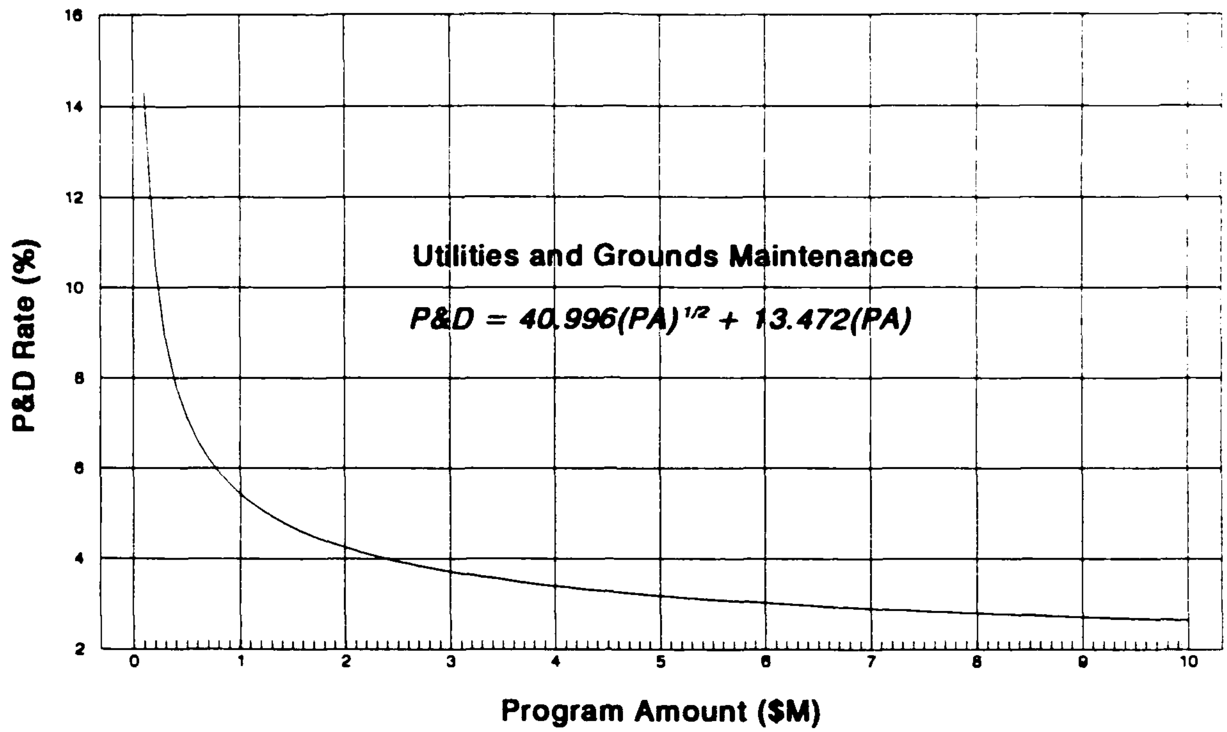
FIG. K–1. P&D RATE CURVES (Continued)

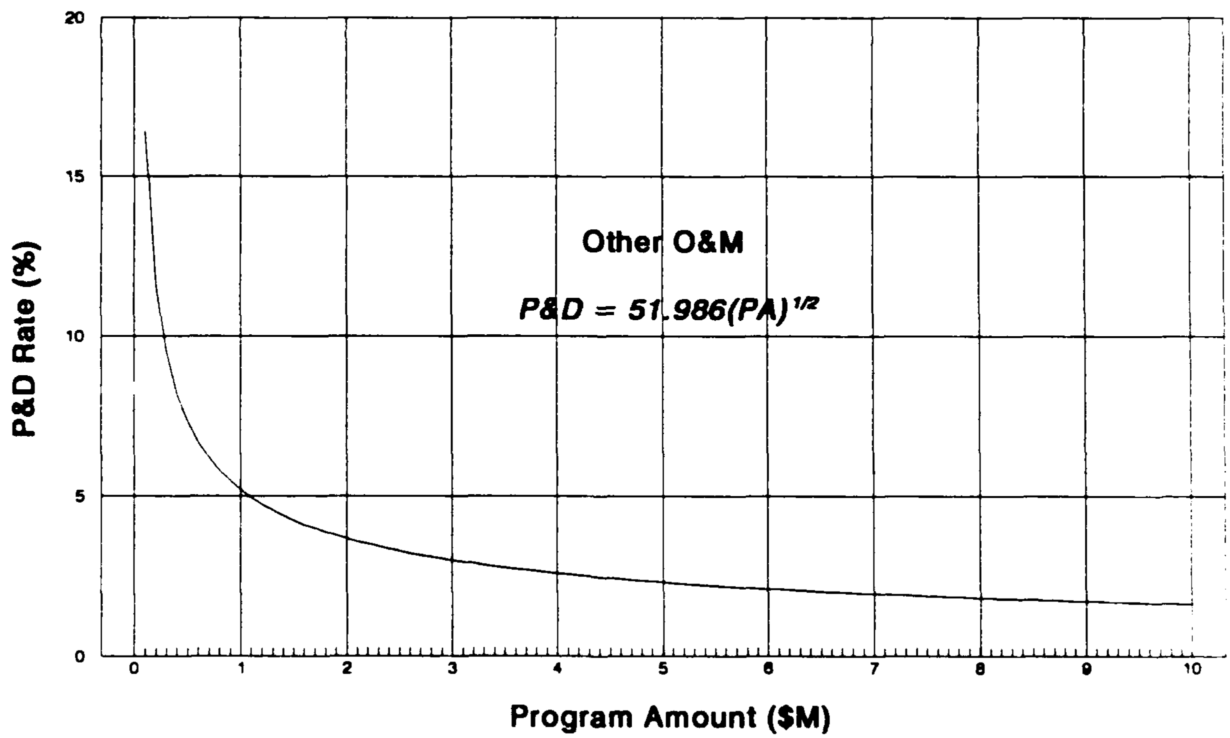




NOTE: Program amount is in 1991 dollars.

FIG. K–1. P&D RATE CURVES (Continued)





NOTE: Program amount is in 1991 dollars.

FIG. K–1. P&D RATE CURVES (Continued)